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SUBJECTS

OF

SOCIAL WELFARE.

BY

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LA BELLE SAUVAGE

PREFACE.

THE selected articles in this volume are confined to subjects of social welfare. There is one exception of a scientific character, in which an attempt is made to explain the causes of sleep. That paper was written many years ago, but it has required only a few sentences to bring it up to the knowledge which we now possess The other articles are of a more recent date, and discuss subjects of national interest I have carefully revised them so as to adapt the subject matter to the existing position of the important questions to which they relate.

LYON PLAYFAIR.

68, ONSLOW GARDENS,
May 8, 1889.

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PUBLIC HEALTH.

ON PUBLIC HEALTH.

NOTE.—This Address was given as President of the Health Section of the Social Science Association, at the Glasgow Meeting.

MY address has been written under peculiar conditions, and requires apology. When the session of Parliament ended, I had not found time to consider even what the subject of the address should be. Since then I have been rambling in Switzerland and Italy, and of course have had no access to books of reference. Under these circumstances, I thought it best to address you in the capacity of an old sanitary reformer; for it was as long ago as 1846 that, as a member of the Royal Commission on Public Health, I published my report on the state of large towns in Lancashire. The memories and gathered experience of a veteran sanitary reformer may not be without interest, even if they are related without that method which would have been more apparent had the address been written in his library.

The first question which occurs is—Are we making distinct and satisfactory progress by our sanitary measures? The answer to that question depends upon our periods of comparison. If we go back far enough in the history of our

country, there are distinct assurances of improvement. Suppose that we begin with the Restoration: although our earlier records relate to London only. For twenty years after the Restoration, there was an exceptionally high mortality, even for that epoch, in the metropolis, and no doubt throughout the kingdom. Macaulay describes it as a time "when men died faster in the purest country air than they now die in the most pestilential lanes of our towns, and when men died faster in the lanes of our towns than they now die on the coast of Guiana." He was right, for the rate of mortality in London from 1660 to 1679 was no less than 80 in the thousand. Let us put in a tabular form the rates of death at various periods since then. The annual deaths from all causes per thousand of the population were :—

1660—79	80·0
1681—90	42·1
1746—55	35·5
1846—55	24·9
1871—80	21·43

If we take the average of the decade ending at the last census, the existing death rate in England is 21·4 per 1,000. Hence one gratifying fact comes out clear and palpable, that the death rate is on the whole continually decreasing in this country, and that the chances of our lives are much better than in the days of our ancestors. If we restrict our view to the periods of the last three censuses—1861 to 1881—we are at first disappointed by learning that the mean age of the whole population was nearly the same—26·4—in these years, and that the rate of mortality is only slightly different, the saving in mortality being chiefly among children of school age who appear to have been brought under better sanitary influences by their removal from squalid homes. But it would be a mistake to suppose that a stationary mortality necessarily

indicates no improvement. The causes of mortality are increasing, and though the mortality remain stationary, there must be improvements in our hygienic arrangements to prevent the deteriorating action. There is a constant disposition among our population to congregate in towns and to leave rural districts. The inhabitants of towns have increased fivefold since 1801, while those of country districts have increased only 75 per cent. In England the town population represents two-thirds; in Scotland, three-fourths; in Ireland, only one-fourth of the whole population. Hamlets become villages, villages are transformed into towns, and towns grow into cities. At the beginning of this century England had no town except London with more than 100,000 inhabitants; now, in 1881, there are twenty. There are fifty towns now in England and Wales containing upwards of 50,000 inhabitants, and these towns contain a larger population than the whole of England and Wales did at the beginning of this century. And as the rate of mortality is largely influenced by the density of population, the causes producing sanitary improvement must be at least equal to those of deterioration. No doubt the death rate is much in proportion to the density of population, but it is not in proportion to the numbers in a city. The death rate of London, that huge metropolis, is only 21·4 per 1,000, or the same rate as that of small Scotch towns, and very different from 30·4, the death rate of Glasgow, or 31·3, the death rate of Greenock. Nor can the difference be due to climatic severities, for while 30·4 out of 1,000 die in Glasgow, only 19·4 die in the rural districts of Lanarkshire. At present (1889) we may take the average death rate of England at 21 in the 1,000, and may assume that a reduction to 17 is attainable, all above that figure being due to removable causes of disease. Let me leave this part of the subject for the present, although I will return to it hereafter,

to consider what are the causes which govern life and death, so far as disease is preventable by agencies over which man has control. My phrase is unphilosophical. Man has not control over a single natural force. He may indeed use the forces of nature, by means of his intelligence, to effect a specific end, but he cannot turn them a hair's-breadth out of their course. The laws of health, like other laws of nature, are relentless in their severity. If you stand on the verge of a precipice and overbalance yourself, the law of gravity relentlessly pulls you down and dashes you to pieces on the base. Equally without mercy are you punished for the smallest infraction of the laws of health, whether you live in cities or in fields. Man, indeed, has no control over a single law of nature; but if he live in obedience to these laws, he will find that they are arranged with supreme beneficence for his well-being. An intelligent submission to them produces health and longevity, while the slightest infraction of them is mercilessly punished with disease and shortness of days. What are these laws? Many are known; others remain to be discovered. For my purpose, at present, I can only refer to some of the more important.

By public health is meant the health of communities, as distinguished from that of its individual members, though necessarily the former is the sum of the positive and negative conditions which act upon the individuals. The health of an individual depends not merely upon existing but also on antecedent causes. Part of his health is transmitted from his ancestors, and may be a mere survival of hygienic conditions which have been extirpated. Part of our health also depends upon the external conditions of our upbringing when young, and part also on the influences, physical and moral, to which we are exposed all through our lives. As there is no individual who can be said to have all his organic functions in the most perfect action, so is there no

community that can be considered in a perfectly healthy state; for the general health depends upon all the moments of the private health of individuals. The health of a nation, physiologically considered, stands closely in relation to that of an individual. The nutrition and health of an individual depend upon the well-adjusted balance of the supply and waste of the particles which compose the body. These particles of the body, all through the life of a man, are incessantly dying, and are being replaced by new particles continually springing into life. Every organ is thus undergoing, through its particles, a continued and rapid alternation of death and life. As the whole body of a man is to one of these particles, so is the whole body politic of a nation to the individuals of which it is composed. The death of an individual in a State is strictly analogous to the death of a particle in a single man, and the birth of an individual in a State is the analogue of the moulding of a new living particle into the body of a man. When an individual becomes diseased, there is some want of balance between the waste and supply of his organs—or rather, of the underlying protoplasm which is so incessantly changing from life to death. When the waste of the ultimate particles is greater than the power of restoration, disease attacks the individual. So in the body politic: when the rate of mortality is too high—that is, when the individuals of its population, which constitute the particles of the State, waste too rapidly—the State suffers from public maladies. Hence the State medical officer and the private physician work on like principles, for to the former the community, to the latter the individual, is the patient. This relation of the individual to the community, and the reflex action of the community on the individual, give a double motive for sanitary action. For the community, depending as it does on all the moments of health of individuals, requires to watch and cherish them; while each individual must feel that it is his

interest to watch the health of his neighbour, upon whose soundness rests the foundation of his own well-being. So that the common law of health is the Christian law:—"Thou shalt love thy neighbour as thyself."

If this analogy between the physiological condition of a community and an individual be real, as I believe it to be, the essential conditions in the health of communities, and of individuals, must be the same. They must be well clothed, well fed, well housed, well aired, and well watered.

The more we consider the question of public health, the simpler does the problem become in theory, though its attainment is difficult in practice All that we need aim to secure is purity or cleanliness in the house, the air, and the water, and genuineness in the food and clothes. In fact, a great part of sanitary science can be comprised in that one word—cleanliness. No epidemic can resist clean houses, clean air, and clean water. Death, like the evil demons of old, shuns cleanly places. In olden times, as among the Jews, evil spirits dwelt in filthy places, especially loving tombs and ordure. Every private closet contained a special demon of its own, and does to the present day in a different sense. I am quite sure that the chamber of Sara, the daughter of Raguel, as described in the book of Tobit, must have overlooked a dunghill, otherwise she would not have been so grievously afflicted by the unclean spirit Asmodeus, who, out of love for her, strangled her seven husbands. But Tobias, her eighth husband, for whom his father-in-law considerately dug a grave as soon as the marriage was performed, obviously knew that there might be smells even too bad for a demon, for, on the bridal night, he threw the putrid heart and liver of a fish on some burning embers in her chamber, and, as the narrative tells us, "the which smell, when the evil spirit had smelled, he fled into the uttermost parts of Egypt." To my mind the book of Tobit is a distinct hygienic allegory. The good Tobit had a

craze for burying dead bodies, and had all his troubles in consequence of his hygienic propensities. Sleeping in a foul place, the sparrows muted warm dung into his eyes and rendered him blind. But Raphael (whose name, by interpretation, means "the medicine of God") comes as an angelic guide to his son Tobias, and puts all things right by his hygienic knowledge—conquering even the foul demon Asmodeus, and curing Tobit of his ophthalmia, acquired, as our workhouse children now get it, by foul air.

The ancients fought against evil smells more vigorously than the moderns. Sometimes, indeed, they simply tried to mask them with perfumes. Thus, when we hear that ancient Capua had whole streets filled with perfumers' shops, we know that it must have been a foul-smelling and ill-governed city. If you were to ask me at the present day what are the best rules for disinfecting foul smells, I could not give you simpler or better ones than those of Ulysses as described in Homer. After slaughtering Penelope's suitors, and scattering their blood and brains over her spacious halls, he first makes a thorough cleansing :—

> "With thirsty sponge they rub the tables o'er
> (The swains unite their toils) ; the walls, the floor,
> Washed with the effusive wave, are purged of gore."

And it is only after thus thoroughly removing every origin of bad smells that he uses a disinfectant to destroy any foul gases which might still lurk in the room :—

> "'Bring sulphur straight, and fire,' the monarch cries ;
> She hears, and at his word obedient flies.
> With fire and sulphur, cure of noxious fumes,
> He purged the walls and blood-polluted rooms."

Contrast the proceedings of the wise Ulysses with those of Eidothea, the daughter of the old sea-god. She fell in love with Menelaus, who, with his two companions, was cast upon the island of her father. To conceal them from

the old sea-god, she wrapped them in the skins of fresh-flayed seals, and made them lie among the flock. Menelaus groaned under the horrid smell of his disguise, till the divine lady brought a powerful scent to mask the putrid odour:—

> "Dire was the ambush, and the scent severe;
> Who could a rank sea-beast at such close quarters bear?
> But she, delivering us, a great help planned,
>   And placed Ambrosia near the lips of each,
> Which in our nostrils breathed an odour bland,
>   And the sea monsters' stench did overreach."

Ulysses was an excellent hygienist, but Eidothea was not. The first went to the root of the matter and first removed all sources of impurity, the latter merely concealed a stench by a perfume. Hercules, too, was one of the oldest and most thorough of the ancient sanitarians. He saved the Eleans from pestilence by draining their marshes, and executed a thorough sanitary operation when he cleansed out the Augean stables by turning into them the waters of the Alphæus. But of all sanitary reformers, Moses was among the most practical. He was learned in the wisdom of the Egyptians, and they, as we know, were hygienists. One of their commandments, though it does not remain among the ten which Moses brought down from the Mount for our guidance, was, "Thou shalt not pollute rivers." The hygienic laws of Moses, supplementary to his ten moral commandments, are full of wisdom. The purifications required by religious observances were in the main hygienic precautions. The ceremonial part still remains in the East as a survival of a purpose which is now forgotten. Moses gave to us the principle of the modern earth closet, and excellent rules for isolating and disinfecting diseased patients and their excreta. He established health officers, or, rather, gave to the High Priest the function of an officer of health. Before long we may be

obliged to enact the ancient laws of Moses for isolating patients with infectious disease, and for cleansing the houses in which it occurred. In the case of cattle, we knock them on the head and kill them, and there is an end of cattle plague. We cannot do that with men. If we could isolate cholera patients and disinfect their excreta, we could as easily prevent its spread as in the case of cattle plague. We do isolate them when they arrive in ships—why not in houses? The isolation of patients afflicted with small-pox, scarlatina, and measles, will one day become a part of hygienic law, though at present it would not be supported by public opinion. In the time of Cardinal Wolsey, plague patients were strictly isolated. Most religious reformers, like Mahomet and Menu, have also been apostles of cleanliness. During the best times of Greece and Rome, public health was much studied. The anatomical and pathological examination of the intestines of sacrifices was a hygienic precaution to ascertain whether the locality upon which a city was to be founded or a camp pitched was in a healthy condition. The supervision of hygienic arrangements was an office of dignity among the Greeks and the Romans. Epaminondas, one of the greatest military geniuses that Greece produced, did not refuse the office of "telearch" at Thebes, though its chief duty was to supervise the cleansing of the streets. For this, Plutarch justly commends him. In like manner at Rome the cleansing and disinfection of streets and sewers were placed under a high officer of State, because, as Justinian tells us, "uncleansed and unrepaired sewers threaten a pestilential atmosphere, and are dangerous." Of the surviving works by which the greatness of Rome is still evidenced, perhaps the first is the Civil Law, but second stands its sanitary works, as evidenced in the great aqueducts, the Cloaca Maxima, and other hygienic appliances. It is, then, clear that the ancients knew as well as the moderns the main conditions

of public health—viz., that foulness is the source of disease, and that cleanliness is its preventive. Purity of the person, purity of the dwelling and its surroundings, purity of the air, purity of the water, purity of the soil—in one word, cleanliness—form the beginning and the end of hygiene. It is chiefly amid great plagues and calamities that men look for more occult causes of disease, such as comets, terrestrial exhalations, volcanic emanations, celestial conjunctions, or the poisoning of wells by Jews, just as now people are apt to refer them to electricity or magnetism. Sydenham himself, that model physician, must look deep down into the bowels of the earth for the causes of epidemics—into the *interiora terræ viscera.* Men would not then look at their own surroundings for a simpler explanation, but fastened on some strange phenomenon which might appear. There are some rough mining districts in this country, where, if a strange traveller appears, the boys run after him with the shout, "Here is a stranger; come, let us stone him!" Philosophers seized hold of any strange phenomenon in like manner, and pelted it as the cause of human woe. But the progress of knowledge brings us back to the simplicity of ancient faith, that foulness breeds the demons who desolate our hearths, and that they cannot abide in cleanly habitations, which they abhor. And so the sum and substance of all our sanitary science accumulated by ages may be summed up in the pregnant advice of the prophet—WASH AND BE CLEAN. It is the simpleness of the remedy as a cure for the public ills which so grievously affect us that prevents its public recognition. If I had talked to you about *schizomycetes*, including bacteria and its allied forms; if I had described vibriones, and all those organic bodies which are floating in the atmosphere, or which appear in decaying substances and in the blood of diseased persons, you might have thought that the chairman of the health section had some sanitary learning, and that

it was worth coming to hear his discourse. But you revolt at the simplicity of his statement, that cleanliness is the beginning and the end of all practical sanitary work. Well, you are not singular. There was once a rebuke to such doubts given on another occasion :—" If the prophet had bid thee do some great thing, wouldest thou not have done it? How much rather when he saith to thee, 'Wash and be clean'?" That cleanliness—both physical and moral purity—is next to godliness, should be the saving faith of every sanitary missionary.

Do not, however, think that I undervalue the numerous researches which have been made in recent years as to the organised causes of disease, whether we call them by such general names as microzymes or *contagium animatum*. I have read all the memoirs on these subjects with the highest possible interest, for the specific characters of diseases lend much support to such views. When you find that the virus of small-pox reproduces small-pox only, and that of scarlet fever breeds scarlet fever only, you are as much inclined to refer their origin to a specific organism as you are to attribute a puppy to a dog or thistledown to a thistle. But the researches on the microzymic origin of disease, though vastly important, are scarcely yet within the domain of practical application. These bodies of low organised types are always associated with foulness. But whether putrid emanations are the result of the growth of these organisms, or whether the emanations form the only soil in which they can grow, neither I nor anyone else can tell you with certainty. Perhaps the problem will ultimately be as unsoluble to philosophers as that involved in the doubt whether it was the first hen that laid the first egg or the first egg that produced the first hen. But what is quite certain is that if filth be entirely prevented, none of these entozoa will permanently remain, and, therefore, the practical maxim should still guide you — Wash and be

CLEAN. But understand this practical maxim in its full significance. I do not mean mere personal or objective ablution, but an uncompromising war with uncleanliness of all kinds. In this way you may use water as an agent, or disinfectants, or drains, or fire, or any other means of utterly removing and destroying all filth and all its consequences.

Let me now give a few illustrations of the consequences attending the neglect of this hygienic maxim. When the civilisation of the Egyptians, the Jews, the Greeks, and the Romans faded, the world passed through dark ages of mental and physical barbarism. For a thousand years, Michelet, their historian, says, too broadly, there was not a man or woman in Europe that ever took a bath. How different that time was from the times which preceded it, when daily baths were common among the poor, you may gather from the praises of personal ablution which abound in ancient authors. Take, for instance, Martial's address to his friend Oppian, on the limpid and unpolluted water in the Virgo and Marcian wave, in which it was rapture to bathe :—

> " Water so bright, and clear, and fair,
> You think no liquid can be there ;
> You're not attending, Oppian,
> You'll die without once having washed, poor man !"

But only think what must have been the state of Europe when thirty-three generations were like Oppian, and never once washed, if their historian Michelet is to be believed. No wonder that there came the wondrous epidemics of the Middle Ages, which cut off one-fourth of the population of Europe—the spotted plague, the black death, and sweating sickness ; and the terrible mental epidemics which followed in their train—the dancing mania, the mewing mania, and the biting mania. But even when the Middle Ages had passed away, and the sun of civilisation was again rising over the gloomy darkness of these centuries, what a

heritage of filth-produced disease still remained! Look at Defoe's or Montaigne's descriptions of the plagues of their day. Montaigne gives us some statistics, which Defoe does not do. The plague at Bordeaux, from which Montaigne fled to his country-house, killed 18,000 out of 40,000 people. It followed him and destroyed whole villages. The harvest was not reaped, the grapes were ungathered, and men's minds were occupied, not with the thought of life, but how to protect their bodies from wild beasts after their death. He gives a terrible picture of one of his own workmen, whose last act of life was to draw the earth over his expiring body. It is not a pleasing task to dwell on the habits of the population, even in our country, in past times. Go back only to the time previous to the Reformation, and you can have no difficulty in understanding why luxury and squalor produced the plagues of the times of the Tudors and the Stuarts. High above all other dwellings were the castles and the monasteries, but the cabin of the peasant was worse than any to be now found in the furthest isles of Scotland. It was made of reeds and sticks plastered over with mud. In these wigwams lived an ague-stricken population. In the towns the mechanics lived in rooms without glass windows, slept on straw beds, and worked in workshops unheated by coal fires. Even in well-to-do houses rushes covered the earthen floors, and got saturated with scraps of food, which remained to putrefy under a new layer of rushes scattered over it, so that the "petremen" came to dig saltpetre out of the floors. Filth, instead of being abhorred, was almost sanctified. The monks imitated the filthy habits of the hermits and saints of early Christian times, for the early Fathers commended them. Even St. Jerome used to praise the filthy habits of hermits. He especially commends an Egyptian hermit who only combed his hair on Easter Sunday, and never washed his clothes at all, but let them fall to pieces by rottenness. St. Antony

never washed his feet. St. Thomas à Becket, when martyred, had under-garments in a state which makes one shudder in the remembrance. And so the monks up to the time of the Reformation, and indeed in part up to the present day, thought, or professed to think, that, by antithesis, pollution of the body indicated cleanliness of the soul. Practically, indeed, it helped to it, because the odour of sanctity which infested these old monks and hermits helped to keep them apart from the temptations of the world; for the world scarcely cared to come into too close contact with these odoriferous saints. But this association of filth with religion was unhappy in its consequences, for men ceased to connect disease with uncleanliness, and resorted to shrines and winking Virgins for cures of maladies which were produced by their own physical and moral impurities. Even the palaces of kings were filthy, according to the Duchess of Orleans' Memoirs of the splendid Court of Louis XIV. Under all these influences plagues were very destructive in England. Men first began to connect them with filth by some striking examples. Thus in 1665, when the Court and Parliament assembled at Oxford, it had an immunity from plague, and the reason of this immunity was traced to the thorough cleansing which the magistrates gave to the city to fit it for its distinguished guests. The great fire of London also taught Englishmen a wholesome lesson, for it came as a great sanitary agent to extirpate the foul nests of disease in the metropolis. And so at last the moderns learnt what the ancients knew very well, that public health can only be assured by cleanliness, and that filth is the parent of disease both among individuals and communities.

Hippocrates, who was the first hygienist to write a whole book on public health, took as his text, pure air, pure water, and a pure soil, and you see we have arrived at nearly the same view of the essential conditions of health.

Napoleon, as a result of long experience in the hygiene of armies, came to the same conclusion, for he said to Autonomarchi at St. Helena:—"Life is a fortress which neither you nor I know anything about. Why throw obstacles in the way of its defence? Water, air, and cleanliness are the chief articles in my pharmacopœia." And so are they in the pharmacopœia of the public health medical officer. Let us consider them separately. Air is of all things the most familiar to us, and the one most forced on our observation. To breathe it is our first act of life; the inability to respire it is the last act of life, and is followed by death. All during life it is never absent from our voluntary or involuntary actions. Surely we ought to know everything about this familiar object; yet, in fact, we are by no means intimately acquainted with it. During my lifetime it has incessantly presented new phases to closer observation. When I was a student of chemistry at the Andersonian University in this town, a pupil of my dear friend Graham whose statue now adorns George's Square, air was a mixture of oxygen and nitrogen with moisture and accidental quantities of carbonic acid. Then when I went to Giessen to study under another dear departed friend, Baron Liebig, I learned for the first time that it contained ammonia, and that this, with the carbonic acid, constituted the food of plants. Then, as years passed, nitric acid and ozone were found in it. Still later it was found to contain organic matter in decay and multitudes of living organisms, which exercise much influence on decay and putrefaction. When such interesting strangers are born in the lifetime of an individual during half a century, how little do we know of any object the most familiar to us! Of the air that we incessantly breathe, and of the water which we continually drink, our knowledge, even now, is far from complete. But this we do know, that air—pure, free, and abounding air—contains within itself the power of

purifying itself from all the abominations which we pour into it, and that it is a wonderful mechanical scavenger for carrying away all gaseous impurities. If you only imitate the ways of nature in your hygienic arrangements, they will be fruitful in good results. The excreta of animals during life, and their bodies after death, all pass through the processes of putrefaction and decay, and in new forms enter the atmosphere. With such a mass of festering corruption in the world, there must be some provision, not only to render these gaseous emanations innocuous, but also to convert them into objects of positive utility. The first process is never to allow the contaminated air of one part of the atmosphere to remain in the same place. By the great polar and equatorial currents, and by the local winds, which are mere eddies in these great streams, the putrid emanations are spread uniformly throughout the atmosphere, and when made truly gaseous they are still further mixed by diffusion. The oxygen of the air chemically attacks the organic matters of the miasms and foul products of decay, and burns them up as completely as if they were passed through a fire. Their organic character is thus destroyed, and they pass into the inorganic forms of carbonic acid, water, and ammonia, which are, in fact, the food of plants. The ozone of the air is oxygen in a more active form, and is a strong burner-up of decaying matters. Supposing, however, that a shower of rain washes some of the foul matter out of the air before its oxidation or burning is complete, the air follows it to the soil, which from its porous character absorbs oxygen, and thus the soil acts as a disinfectant, and prepares the foul materials to become the food of plants.

This conversion of putrid matter into carbonic acid, water, and ammonia is undoubtedly the final result of natural purification. The desire to attain it speedily has been recently expressed in the attempts to revive the

cremation or burning of dead bodies. I quite approve of the end proposed, though I am not quite clear as to the means of producing it. Burial in a porous soil produces the same results, and if the earth be sufficient and well selected, it does so inoffensively. Then the bodies decay, not by putrefaction alone, but by eremacausis. That word, which is merely the scientific word for decay, is derived from two Greek words meaning slow burning. So a porous soil, containing sufficient loam to be absorptive, is in fact a slow furnace, where burning is complete in itself.

How differently do we act in our civic arrangements! Instead of allowing garbage to be freely oxidised, or applying it to plant life, which is its natural destination, we dig holes close to our own doors, and cherish the foul matter in cesspools under conditions in which air cannot enter freely, and which are the most conducive to injurious putrefaction. We forget the experience of our forefathers, that every cesspool has its own particular evil spirit residing within it; and we are surprised when the demon emerges, especially at night, and strikes down our loved ones with typhoid fever or other form of pestilence. Perhaps we go a step further in the hygiene of moderns, and do throw the foul matter into drains, which empty themselves into our once beautiful rivers, which in many cases are still used as a beverage by people lower down in the stream. And when they remonstrate with us, we, surly wolves, growl at the poor innocent lambs lower down the stream, because they object to drink our abominations. This country once gloried in her beautiful rivers, but they are now mere open ditches, which pollute the districts through which they flow. Rivers in their normal state contain dissolved air sufficient to oxidise and destroy any accidental organic contaminations. This purifying power of air dissolved in water is essential, because no water,

either in rivers or springs, could otherwise be pure. All sources of water are ultimately obtained from rain, and that is never pure, because it washes out organic impurities from the atmosphere. At the same time it carries down air in solution, so that it brings with the poison its natural antidote. The air-purifying process is, however, limited, and is altogether insufficient for streams polluted with town sewage and manufacturing refuse. In them you find no free oxygen, for that has been used up by the first small portion of impurities poured into the streams. Take, for instance, the beautiful Clyde, which ought to wash, but which fouls, this great city. I have analysed its waters miles above and miles below Glasgow. Long before it reaches the outskirts of the city it is already fouled, but after passing Broomielaw its condition is abominable. My friend Dr. Angus Smith has analysed the waters in its isthmus, and has found these pollutions even in the water of the beautiful sea-bathing resorts which are so much frequented by the upper classes of the city. The self-purifying power of rivers, and even of the sea pouring in its tidal wave to dilute them, has no chance against the mass of abominations which large towns pour into them. But there is no longer an excuse for their doing so, for there are now various effective and well-matured processes for purifying drains before the water is ultimately discharged into the river. You cannot take out these abominations from the river itself, but you can readily prevent them being put in. Coleridge saw this when he wrote so fiercely on the foul smells of the city ot Cologne :—

> "But tell me, Nymphs! what power divine
> Shall henceforth wash the river Rhine?"

The only mode of restoring our great rivers from their present condition of open ditches to their natural purpose of watering and purifying the districts through which they flow

is to prevent polluted matters being poured into them. Parliament must enact for this country the ancient commandment of the Egyptians, and say to all municipalities and manufacturers, "Thou shalt not pollute rivers." They have already said so to the latter in regard to air. When I was a student in Glasgow, I remember that the tall chimney of St. Rollox used to vomit forth noxious vapours, destroying vegetation and annoying the inhabitants. I had some small influence in persuading the late Lord Derby to pass an Act forbidding the pollution of air, and I am sure that the Messrs. Tennant and all other soda manufacturers are glad that we forced them to condense their acid fumes. Well, I say with perfect deliberation, and after full study of the subject, that our knowledge in regard to the purification of drain waters, whether these contain town sewage or manufacturing refuse, is abundant and practical, and that all municipalities and manufacturers should now be prohibited by heavy penalties from fouling rivers. The compulsion would be a positive benefit to both. I may remind you that the Prime Minister (Mr. Disraeli) has lately told a deputation that he is greatly interested in this object. I hope that he is destined to do for water what his former friend and political chief, Lord Derby, did for one of the many impurities in air. Such a triumph of sanitary legislation would be worthy of the great State doctor who has taken as his motto "*Sanitas sanitatum omnia sanitas.*" If he achieve the purification of our rivers, I am sure that I can promise him from this Association, and indeed from all political parties in the State, an amount of applause which can best be expressed in the words, if not in the meaning, of Macbeth, when he says :—

"Come, sir, despatch ; if thou couldst, doctor, cast
The water of our land ; find its disease,
And purge it to a sound and pristine health,
I would applaud thee to the very echo
That should applaud again."

Mr. Disraeli has obviously thought much about subjects of public health, as evidenced in the wise observations of Mr. Phœbus in "Lothair." When, then, in his celebrated Manchester speech, he pledged himself that a Conservative Government would devote special attention to sanitary subjects, I believe that he expressed a deliberate and mature conviction. But hitherto, probably from the force of circumstances, we have had promises only, without their fulfilment. Surely many Sessions cannot pass without a serious attempt at sanitary reform, when we recollect that the Prime Minister of England (Mr. Disraeli) is the same orator who used the following remarkable words :—"I think public attention ought to be concentrated on sanitary legislation ; I cannot impress upon you too strongly my conviction of the importance of the Legislature and Society uniting together in favour of these important results. After all, the first consideration of a Minister should be the health of the people."

In the recent progress of hygiene nothing has been more clearly proved than that diseases are largely propagated through foul water, and recent investigations seem to point to the unpleasant circumstance that the germs of disease chiefly come from the excreta of men as they enter into a state of putridity. Whole villages and streets in large towns have been stricken with disease by portions of human excreta finding their way into water. Take the fever epidemic in London last year. A dairy company used the water of a well which had received the drainage of a person infected with fever, this drainage having percolated through the soil to the well and contaminated it in the usual manner in which well-water is so constantly fouled. Hundreds of persons, among whom were some of my relations, were stricken down by the milk polluted with this impure water. Take as another example the case which has happened while this address is passing through the press. A large

public school, supported by national subscriptions, is thoroughly wrong in its hygienic arrangements. In its cisterns are foul waters, and close to its playgrounds are filthy cesspools. A most distinguished sanitarian—Dr. Anstie—visits it, and is lost to the world and to science during his inspection. Let us hope that the sacrifice of this precious life may lead to much sanitary improvement in our public schools. When the virus of disease enters the body in a state of solution, it is in a state most favourable for development. And as water is the common vehicle for removing impurities from dwellings, it becomes especially important to prevent waste water from entering into any source of water supply which is to be used for drinking or any other domestic purpose. But what is the condition of many towns, such as London itself? They are situated on rivers from which their water supply is derived, and it may be, and often is, the case that hundreds of thousands of persons pour their abominations into the river before it is used for the town lower in the stream. London in this way has to drink all the foul drainage of about a million persons above it in the stream. The people cannot realise this nastiness, or they would not tolerate it for a day. Glasgow is happily situated in this respect, for it receives the pure and soft water of Loch Katrine. If London had such a source of supply, I believe that it would stand as a model in its death rate to all the towns in the kingdom.

From what I have already said, you will observe that the natural purifiers, on which we should rely in combating the pollution of our cities, are a free supply of untainted air, unpolluted water, a porous soil (the pores of which are open and not filled up by undrained waters), and, let me add, a healthy vegetation in the squares of our towns to help to purify their atmospheres and to pour into them life-giving oxygen. It is the want of these conditions which makes both town and country dwellings unhealthy.

In ancient as well as in modern hygiene the importance of an adequate ventilation of streets and houses was well known. It was also a matter of recognised experience that even efficient ventilation of these would be of little use unless the ground on which they were built was also ventilated; that is, drained of underlying water, so that the air might penetrate and circulate freely through the porous soil, in order to disinfect it from the continually accumulating *débris* of a crowded population. A few years since, while wandering amid the ruins of Cæsar's palace at Rome, I was stricken with the well-known fever of that city, and during my convalescence I had ample time to speculate on its causes. Those of you who have been in Rome will recollect how shallow now is the depth of the Tarpeian rock, and how deep down below the level of the surrounding streets are the floors of the Forum and ancient temples and palaces. All that is above them is the organic and inorganic *débris* of thousands of years, which when stirred up, and coming in contact with oxygen, begins again to decay, and continually emits those exhalations which find their expression in the Roman fever. The same is the case on the site of ancient Jerusalem. I remember to have read somewhere that when a shaft is sunk to the base of the Temple, the decaying matter of many past generations is set into action, and quickly destroys the wood with which the shaft is lined. Unless, therefore, the soil upon which a city is built is well drained and ventilated, the dwellings of the city cannot be healthy. It is not in fevers alone that the influence of the soil is apparent. Probably consumption itself, that great scourge of this country, is a chronic zymosis or disease like many of our fevers, arising and communicable from like hygienic deficiencies. It is greatly mitigated by drying and ventilating the soil, as well as by ventilating the dwellings. After the sewerage of Salisbury had been made effective, the deaths from phthisis

fell 49 per cent., in Ely they fell 47 per cent., in Rugby 43 per cent., and in Banbury 41 per cent. Dryness and elevation, and well-ventilated rooms, are powerful means to prevent as they are to retard consumption. In the last generation the average period of that sad disease was two years. Now, according to Dr. Williams, it is eight years. With pure air in the soil and in the dwelling, let us hope that the succeeding generation will point to it as a rare disease instead of as one of the most common maladies of this country.

Free ventilation around the houses, as well as within them, was enjoined by the ancients, but was as much neglected by them in practice as it has been by the moderns. Zeno ordered, after a long neglect, that houses in Constantinople should be twelve feet apart all the way up. His orders were disobeyed, but fire in Constantinople has repeatedly done for it what fire has done in London. Ancient Rome, like modern Glasgow, became very bad with its closely built houses, and at last they were ordered to be five feet apart, and not more than nine storeys high. Augustus limited their height to 70 feet, and Trajan to 60 feet. We do not know how many people lived in these houses, or how many congregated on an acre. But we do know some facts as regards our own population. Taken on an average all through England, the towns are less packed with houses and people than one could have anticipated. In primitive countries, where the savages live on the produce of the chase, there is one inhabitant to each square mile. In the time of our Saxon ancestors in this country there were five houses to each square mile, and probably about thirty inhabitants. Good but high-handed Queen Elizabeth was so horrified with the gigantic growth of London, although it then contained only 160,000 people, that she forbade the erection of any more buildings within three miles of London and Westminster, and she prohibited

the division of a house into tenements for various families, "because" (I quote her own words) "great multitudes of poor people inhabiting small rooms, and those very poor, and such as must live by begging, or worse means, being therein heaped together and in a sort smothered, with many families of children and servants in one house or small tenement, it must needs follow that, if plague or sickness came amongst them, it would presently spread through the whole city and confines." Well, does this not sound like modern lecturing in the crowded city of Glasgow, where noble and gallant efforts, however, have recently been made to mitigate the evil, and with a large promise of success? In Queen Elizabeth's time there were 15 houses, and 83 people to the square mile in the whole of England. Now there are 73 houses and 390 people. In all the English towns—excluding the rural districts—there are 713 inhabited houses, and 4,061 inhabitants, to a square mile. That gives nearly an acre to each house containing six persons. You see, therefore, that the area of a town is far from being wholly occupied. But just compare that with large parts of Glasgow before the passing of its Improvement Act in 1866. Instead of 6 people to an acre, which is the urban average in England, there were districts with 600 people to the acre, 50,000 people being huddled together on 80 acres. Even now, Glasgow contains 100 persons to the acre; while London and Edinburgh contain about 46 to the acre. In 1871, when the census was taken, only 5½ per cent. of all the families in Glasgow had more than four rooms, or, in other words, 94½ per cent. of the families had such insufficient accommodation that in no case had they more than four rooms, and in most cases fewer. In fact, nearly one-half of the population of Glasgow (exactly 46 per cent.) live in one-roomed houses. Edinburgh has 78 per cent. with the scant accommodation of under four rooms, and 22 per cent. with the superior, and its rate of mortality is

25·7. If you now compare by a simple rule of three the relative density of population with the relative mortality of Edinburgh and Glasgow, you will find that the increase of mortality in Glasgow nearly corresponds to its increased density in population.

The four towns of largest mortality in Scotland—Paisley, Dundee, Glasgow, and Greenock—have such dense populations that from 93 to 94 per cent. dwell in houses with four rooms and under. Notwithstanding the efforts made in Glasgow and Edinburgh to improve the house accommodation of the poor, the latter often defeat the intentions of those who built capacious houses, because they overcrowd them with lodgers. The working man does not spend the same proportional amount on rental that the middle-class man does, and is apt to try to decrease his weekly house payments by adding lodgers to the other inmates, who are already amply sufficient for the accommodation provided. If a room be adequate in its cubical contents of air for one person sleeping within it, yet it may be wholly inadequate for two or more persons. Although the amount of air required by an individual for respiration is comparatively small, yet he fouls so much air both by carbonic acid and organic exhalations, that a large quantity of air must pass through an apartment to keep it sweet. If the air contain even one cubic foot of carbonic acid to 1,000 cubic feet of air, it is vitiated air in an apartment. Now, to keep pure air in a room, from two to three thousand cubic feet should be allowed to pass through a chamber every hour for each person sleeping or living in it. I need not trouble you with the data for this assertion. It is not a large enough allowance for hospitals or for rooms where there are exhalations of the sick. Unluckily the prevailing impression is that a far smaller amount of air suffices. In schools, for instance, often not one-fifth the amount of ventilation is given which is requisite for health.

Our rooms would become intolerable if it were not that there are natural, though insufficient, sources of ventilation beyond our control. The walls and mortar, though not transparent to light, are transparent to air, and through them is constantly passing an interchange of vitiated and pure air. Brick is, however, more porous to air than sandstone or limestone, and Scotch houses are not so easily ventilated by natural means as English houses. Indeed, were it not that the mortar which joins the stones happens to be readily permeable to air, stone houses would be in a bad condition. Of course it is obvious that the fewer persons there are in a house or room the greater becomes the superficial area of the building to each individual, and the more efficient the uncontrollable ventilation. Still air is of little use in ventilation, for the origin of the word (*ventus*, wind) indicates that there must be air in motion. There are only two practical modes of producing this in our dwelling-rooms. We must either admit the external air when it is in motion, or we must produce movement by an elevation of temperature, such as fires, within the room. As the pernicious effect of draughts on susceptible persons depends on an abnormal cooling of the body, the task of the ventilator is to obtain efficient change of air without chilling one part of the body more than another. The problem is to effect this without producing a draught, for we all remember the warning :—

> "If cold wind strike you through a hole,
> Go make your will and mind your soul."

In modern hygiene nothing is more conclusively established than the fact that vitiated atmospheres in our dwellings and their surroundings are the most fruitful of all sources of disease. The exceptions to this statement are easily explained. Thus, in the wretched dwellings and filth-polluted premises in the islands of Scotland, you would expect to

find a large rate ot mortality, when in reality it is comparatively small. The reason is that during the day the inhabitants respire pure air, and during the night it circulates freely through their badly constructed cabins, neutralising the foulness in which they are content to live. But in great cities like Glasgow there is no ozone-bearing air within miles of any part of it, and the houses are built of materials which render natural ventilation difficult. Then comes the packing up of the population into an incredibly small area, and the death rate tells the woeful result. There is no subject to which I look with more interest than to the results which may be expected from the vigorous effort which the municipality of this city has made in recent years to mitigate this evil. The example is already telling on London, and I hope that the efforts of my friend Sir Ughtred Kay-Shuttleworth, and others, will be crowned with success, and that we shall see a large effort to improve the dwellings of the poor in the metropolis. Light and air are as necessary to the dwellers in cities as they are to the trees of a forest. There you see trees, pining for air and light, push their branches in the direction of every inlet In their struggle for existence many are dwarfed and come to nothing; a few, stronger and more robust in constitution, push aside the weaker, and appropriate the essential conditions of life to themselves. If the forest be under skilled care, the forester, with his pruning knife, cuts down the weak saplings, and leaves sufficient space for air and light to those of promising growth. But in an overcrowded city, grim Death with his scythe exercises little discrimination, and cuts down all those who come within its fell swoop. I have only alluded to the physical evils of overcrowding; but the moral evils are greater still. Although there is an excessive rate of mortality in overcrowded districts, there is no lessening of the population by such unhealthy agencies. A crowded and unhealthy district,

with all its inevitable consequences of low morals and low intelligence—where the condition of human beings is scarcely above that of animals—where appetite and instinct occupy the place of higher feelings—where the barest means of support encourage the most improvident and early marriages—is not the place where we shall find a diminishing or even stationary population. For the early unions in such places are followed by early offspring; and although more than half that offspring may be swept away by disease during infancy, yet nearly a third of it will grow up in spite of all the surrounding evils, to follow in the steps of their parents, and in their turn to continue a race, ignorant, miserable, and immoral as themselves.

Next session the Friendly Societies Bill purposes to deal with some of the many causes of juvenile mortality. The death rate of children in a district is a sort of hygienic barometer of the surrounding physical and moral atmosphere. It is in a falling state in Scotland. The deaths among illegitimate children especially are on the increase. That is new in Scotland, but it is old in England. In some districts in London their rate of mortality when put out to nurse was 70 to 75 in the hundred within the first year, and in many manufacturing towns the deaths of illegitimates are 30 per cent. King Herod was not a more efficient baby exterminator than such hired nurses. But there are many moral causes of infantile mortality besides illegitimacy. When I reported on the hygienic state of the large towns of Lancashire in 1846, I was much censured because I dared to show by statistics that the children insured in burial societies died faster than uninsured children. That parents should neglect their children for their burial money is very horrible; but the conviction that they do so was strongly forced upon me by the evidence, and twenty-eight years later it is again forced on public attention by the far higher authority of the Friendly Societies Commissioners. In

1846 I also was distressed to find the use of opiates among children very prevalent in manufacturing districts. In this case the motive was not criminal, for the practice had arisen in ignorance of its bad effects. But it was not difficult to trace a large amount of direct and indirect mortality to this pernicious custom. Among children the administration of opiates, under the names of quieters and soothers, is nearly as destructive to health as the excessive use of alcoholic stimulants among adults. The craving for both arises from those depressing physical causes of disease which abound in cities. Dirt and drunkenness are often cause and effect. Indeed, the physical and moral causes of disease are nearly as intimately associated as filth is with the entozoa of which I have already spoken. Shocking and repulsive as some of these causes are, especially in relation to infantile mortality, it is no use for us, like ostriches, to bury our heads in the sand and refuse to see them, for it is the relentless King Death who is our pursuer. I have sometimes been unwise enough to think that the enormous infantile mortality of our crowded places might be an important provision for securing a more healthy race of survivors in the struggle for existence. But a little reflection shows how untenable such a view is. We might as well suppose that the abnormal waste of a particular organ of the body was best fitted for the health of an individual as to consider that the increased mortality of unhealthy districts in a town gave a superior race to its surviving inhabitants. No doubt unsanitary conditions first sweep off the weak, and those unfit to live under the continuance of existing causes of disease. But these become stamped at the same time into the organisms of the survivors, who carry them through inheritance into succeeding generations, though the original causes may have been removed. The survivors carry with them the seeds with which they have been impregnated during an unhealthy upbringing :—

"A man, perhaps the moment of his breath,
Receives the lurking principle of death;
The young disease which must subdue at length,
Grows with his growth, and strengthens with his strength."

We are not always neglectful. Sometimes we look upon a human infant as a dangerous animal that may turn round and bite us when it grows up, and so we give some attention to the children of the dangerous classes, and try to tame them by improving their dens and educating them to a limited degree. But the children of the productive classes receive no such public care, and they grow up stunted in frame and of low productive value, because the State does not provide for conditions of healthy human development in crowded populations. If babies were pigs, or oxen, or sheep, the Vice-President of the Council would be daily questioned in the House of Commons if any unusual mortality came amongst them; but being only human infants, no one thinks of their welfare. Beasts, with a selling value, are taken more care of than men in free countries. I do not remember the proportion of veterinary surgeons to horses, and of surgeons to men in our own army; but I recollect that Chenu, in describing the late French war, said that every 1,000 horses had 4½ veterinary surgeons, while every 1,000 men had only two surgeons. If we succeeded in getting the dwellings of our working classes made as healthy as the cell of the felon—and surely that is not an unattainable luxury—eight years would be added to the productive ability of our working population.

I have mentioned various subjects in regard to which legislation is promised to us by Government, and I have no doubt of their desire to improve the condition of the people; but there is among their supporters a strong objection to increase local taxation, and without that large

measures of improvement cannot be carried out. I should like, therefore, to show you by a single illustration how productive local taxation is. Sanitarians at present are inclined to believe that urban deaths need not exceed 17 in the 1,000. Let us assume, in the case of Glasgow, that its death rate might be reduced to that of London—that is, to 22·4 in 1,000. In this case, the unnecessary and preventable deaths in Glasgow, as compared with London, are 3,817 annually. But these deaths imply a far larger number of cases of preventable sickness among the living. Statistical investigations made by Pettenkoffer show us that for every case of death in public institutions for the sick there are 34 cases of serious sickness, so that the 3,817 unnecessary deaths must be multiplied by that number in order to give you the minimum cases of preventable sickness. These cases of sickness last on an average 18½ days. Hence the cases of preventable serious sickness, taken at only two shillings a day, represent an annual cost to the city of Glasgow of £240,000. This, however, represents only a portion of the interest of money which might be well spent in paying borrowed capital for the improvement of the city. I put this for the present purposely on the mere money aspect of the question. Emerson's aphorism, "Public health is public wealth," is true even in its more vulgar meaning. Whether the saving of life of human beings, with higher hopes and aspirations than existence in the world, is to be appraised on a mere money standard, is quite another question. My object is simply to show that, taking the smallest part of the money saving, it is obvious that money judiciously spent in sanitary improvement is not unproductive taxation, but capital bearing abundant interest.

I began by discouraging statements of our slow progress in the improvement of the country as a whole. As regards Scotland, indeed, I had to admit that the causes of

deterioration are still more powerful than the means of improving the social condition of the people. If I understand my countrymen aright, the conviction of this fact will not render them hopeless, but will stir them to new exertions. Yet I would not take leave of you without pointing out that there is abundant proof that sanitary measures are producing great results when well applied. Take the case of the army, for example. About twenty years ago, if my memory serve me right, I was a commissioner of inquiry into the hygienic condition of military barracks. Then their ventilation was in a woeful condition. I spent various nights in the sleeping-rooms of the soldiers, and found all the hygienic arrangements deplorably bad. Since the Crimean War, the military authorities, aided by the excellent hygienists among the medical officers of the army, have placed the health of the army in a much more satisfactory condition, and the result is that the mortality of the army is now less than half of what it was before the war. Our troops in India used to have a death rate of 67 in a thousand. This is now (1888) reduced to 20 in a thousand. It is not in our army alone that such results have been produced. Formerly the deaths from sickness in campaigns were four times greater than the deaths from wounds. Every campaign now lessens the proportion, because the sanitary conditions of the soldier's life, both in peace and war, are much better attended to. In the last war the German troops lost less than a third of their dead by disease, while formerly the loss had been four times that from wounds. The Germans have recently made great advances in the health of their troops. Cleanliness is specially enforced. Means of washing the bodies of half a million soldiers are provided at the cost of a shilling for every hundred men. The mortality of their soldiers in peace is said to be reduced to six in a thousand. The small loss from disease as compared with wounds in the French war, promises

much for military hygiene in future campaigns. In the Crimean War, after the sad experience among our own troops owing to defective sanitary organisation, we sent out a sanitary commission, and improved the hygienic condition of our troops, while France failed to do so. And the final result, according to Chenu, is that while we lost 12 in the 1,000 of our men, France lost 155.

Formerly the rate of mortality in the chief towns of British India, such as Calcutta and Bombay, was appalling; now, by hygienic improvements, and in spite of the tropical climate, it scarcely exceeds that of Manchester,. Liverpool, and Glasgow.

If I had time I could quote to you many cases in England where sanitary constructive works have largely reduced the mortality, but I have taxed your patience too long, and must now draw to a conclusion.

I have indicated the promises of sanitary legislation which have been given to us by the present Government, but to none do I attach more importance than a reorganisation of our system of local government, which the Conservatives are bound to attempt. If wisely done, its consequences may be immensely beneficial. In England, at the present time, there is a casual agglomeration of 1,500 separate sanitary authorities, without system or cohesion. Their areas of administration are diverse in the extreme, being neither bounded by counties, parishes, nor natural watersheds; and their duties are divided without meaning between authorities in the same district. They have been lately put under medical officers of health without preparation or qualifications for their duties, some well paid and devoting their time to this important work, others having little more than nominal payment and giving little more than nominal time to their important duties. Notwithstanding this too sudden and unprepared universal appointment

of medical officers, yet in the administration of the Health Acts there has been recently manifested a disposition to "distrust the doctors," and to work the Acts, at least at headquarters, by lawyers and other persons not connected with the medical profession. This is the old error, which Archbishop Whately and others have so effectively condemned, of making common sense the fetish for worship. Even the most fervent worshipper of common sense, as opposed to technical training, never relies on it in important emergencies of his life. He goes to the lawyer to make his will or to convey property; he consults the parson on religious doubts when on the sick-bed; and he does not spurn the doctor to cure him of his grievous ailment. Yet it is well known that the Local Government Board are afraid of the doctors in the administration of Health Acts. Who besides them possess the knowledge? I can testify, from an experience of thirty years in sanitary work—and impartially, because I am not in the medical profession—that there is not a class of men in the country who labour so zealously for the prevention of disease as the doctors, though their training hitherto has been cure, not prevention. Certainly their private interests have never been allowed to stand in the way of their efforts to uproot disease, although their living depends upon its existence. This unselfishness in the application of their science to prevention has always been to me a source of high admiration. Why, then, is there this vulgar distrust of the doctors in the administration of our Health Acts? Extend this prejudice against technical knowledge, and how absurd it would be! Would you improve the progress of telegraphy in this country by suppressing electricians; or the law and justice of the country by putting down lawyers? Would the Secretary at War promote the conduct of war by suspecting soldiers; or the First Lord of the Admiralty the efficiency of fleets by distrusting sailors? Would our rail-

roads and harbours be better governed if engineers were held at a discount? But this is actually the state of things at the Local Government Board—the Health Ministry of the country. The Privy Council handed over to that Board Dr. Simon and his associates, with a wealth of medical experience in public hygiene; ever since, that wealth has been locked away from public use. Certain I am that their experience could not have guided the Board in the utter confusion of organisation in regard to medical officers of health. They have been appointed without any system. Some have a small parish to attend to; others have a thousand square miles. The latter, unaided by assistants, have the charge of large areas, made up of separate local boards, over which the medical officer has no authority to enforce the removal of sanitary defaults. The officers of health are without any definite rule for obtaining available knowledge of prevailing sickness, even when it is treated at the public expense within their own districts; and they are not, universally at least, informed of the deaths as they occur. The medical officers of health have been appointed without any examination on their knowledge of State medicine, and in the majority of cases they do not possess this knowledge. I am perfectly certain that this utter confusion could not have resulted had the Local Government Board consulted the experienced State medical officers belonging to them. This distrust of the doctors in higher administration is simply a general mistrust of science. And the time has now arrived when science must be trusted in government. Science is entering into the higher education of the country, and the prejudice against it among legislators, who were educated in classical universities, will in time be removed. For the progress of a country depends upon the progress of science, and the welfare of a nation is secured by the most intelligent application of science to its manufactures and to its

government. The health of the country—and that governs the productive power of its people—depends as much upon the right application of medical science as the working of a machine depends upon a good application of mechanical laws. To trust the whole administration of Health Acts to poor law inspectors and lawyers is an amazing example of unbelief in the first principles of the laws of health. The well-being of the people depends upon physical causes, which, when intelligently understood, mean physical science, and the trained physician is the natural and most intelligent agent for extending its knowledge and application to the prevention of disease.

What we want in the future is not new law, but more efficient administration of existing law. To heap up new sanitary law on the decaying mass of indigested sanitary law which already forms a dismal agglomeration, is like the practice of our ancestors, who thought that a few clean rushes, thrown upon the corrupt mass of foul rushes on the floor, sufficed for sanitary purposes. What we want is superior organisation and efficient administration of existing law. But, in our happy-go-lucky style of government, are we likely to get it? It would be as absurd to put a man trained in physical science at the head of the branch of police and justice, as it is to put a man merely trained in law in charge of the physical interests of the people. It is an exploded fallacy that only lawyers are good men of business, and that scientific men are not. Is my friend Sir John Lubbock a worse banker because he is an eminent man of science? Is Mr. Spottiswoode a worse printer because he has distinguished himself as a physicist? Is Mr. Warren De La Rue a worse stationer because he is equally conspicuous as an astronomer and as a chemist? The local government of the country, in as far as it relates to the physical interests of the people, will remain an example of arrested development, unless science receives a

recognised position in its administration. Now, the Local Government Board is drifting into the position of a large and responsible ministry dealing with the physical interests of only one portion of the people, and having no imperial object or comprehensiveness; for though it includes England, it excludes both Scotland and Ireland.

I have already shown that the sanitary conditions of Scotland are deteriorating, while those of England are improving. The natural course of administration, then, should be to bestow upon the former even a greater portion of ministerial care and responsibility; but it receives none at all. The time may, however, arrive when English legislators will remember that there is a certain portion of Great Britain to the north of the Tweed, and that its local government, as well as that of England, is worthy of imperial care. In questions of such imperial importance as education and public health, it is a foolish policy to treat the three parts of the kingdom by fragmentary and unconnected legislation. In relation to sanitary questions, public conscience has been recently much aroused, and will ultimately obtain attention to its calls. No doubt sanitary science, both in the abstract and in its application, is, like many other sciences, of slow growth. The crop of truths which we are now harvesting results mainly from seed sown by our forefathers. The seed which we ourselves may throw upon the waters will assuredly come up into a harvest, though it may not be for many days. But he who will not sow for futurity deserves nothing from the past. It is our duty to labour for a future which we may never see, and not merely to live on the wealth of accumulated experience, as the heir of riches does when he uses them for himself alone. This Association contains many missionaries for the propagation of sanitary knowledge. Their mission is to stand between the living and the dead, and bid the plague to cease. There have been times when a Scotch professor

like myself dared not have preached such doctrines in Scotland, for his countrymen once hugged the belief that pestilences were divine judgments, which ought not to be interfered with by human agency. Even then they forgot that there is far more of mercy than of wrath in all divine arrangements. Undoubtedly pestilences are warnings that man is transgressing the beneficent laws provided for his well-being. But a god of wrath and pestilence is now a god of the heathen, not of the Christian. That ought to have been understood long ago. The prophet heard the wind which clave the rocks, but the voice of God was not in the wind. He felt the earthquake which shook the world, but the voice of God was not in the earthquake. He saw the fire, as it pursued its track of desolation, but the voice of God was not in the fire. It was only after these terrors had passed away that the prophet heard the voice of God as a still small voice. That whispers to us still, not in plagues and pestilences, but, when these dangers have passed, as an ever-present voice in all the ordinary occurrences of our lives. It tells us of the beneficent wisdom which regulates all the laws of creation made for our well-being, and not for our destruction. It is by disobedience to them that we are punished by 125,000 persons being unnecessarily cut off every year in this country. Our own acts produce those demons of destruction which the Jews of old credited with the slaughter of the people, and by our own acts we can convert them into preserving angels. I think it is in the epilogue to "The Honest Man of Fortune" that Beaumont and Fletcher thus describe our responsibilities for what befalls us :—

> "Our acts our angels are, or good or ill,
> Our fatal shadows that walk by us still."

The object of the health section of this Association is to show our countrymen how this sacrifice of preventable

deaths may be avoided. That number of deaths implies more than four million two hundred thousand cases of preventable sickness. It is upon these that we must operate, by rooting out the causes which produce them. I began by drawing your attention to the death rates of the country. These have been derived from the excellent system of death registration which we now possess. But there is another system of registration which it would be important to add to our sanitary records—the registration of sickness. Registration of deaths represents the wrecks which strew the shore, while that of sickness would tell us of the coming storms, and enable us to trim our vessels to meet them. Till we have such a system of disease registration, public health cannot be administered with full intelligence. We must not forget that the function of the sanitarian is prevention. His function begins and ends before man reaches his final state of decay, "or ever the silver cord be loosed or the golden bowl be broken . . . . or the wheel be broken at the cistern." When this wheel, or circulation of the blood, is broken, a new and a great wheel begins, involving in its rotation all organic and inorganic matter. In this there is the highest example to us of hygienic organisation. You know how the waste of animals during life, and of their bodies after death, passes into the gaseous forms of carbonic acid water, and ammonia. These substances form the aërial food of plants, which, in fixing and moulding some of their constituents into new forms of organic life, purify the atmosphere of its noxious products, and restore the life-giving oxygen abstracted in the respiration of animals. Thus plants convert the foul products of animals into new food necessary for their growth and development. The great and abounding air into which passes all the foulness of the living, and all the putrid products of the dead, becomes at once the grave of organic death and the cradle of organic life. In this wonderful circle death and life

rapidly appear in correlation; and past generations of animals, by a process of dissolution, produce living generations by a process of evolution. All this is in the harmony of nature, without jar or disturbance. We should strive, in our hygienic efforts, to take part in this great circle, without vainly attempting either by ignorance or by design to mar such wonderfully-conceived plans for preserving the world in purity and sanity.

SLEEP,

AND SOME OF ITS CONCOMITANT PHENOMENA.

NOTE.—This lecture was delivered at the Royal Institution, Manchester, in 1846, and published in the *Northern Journal of Medicine* in that year. As I think, even now, that it contains an adequate explanation of sleep, I publish it, with only some trifling additions, showing that modern discoveries have given confirmation to the views then expressed.—L. P.

THE researches of Liebig have lately shown that much information may be obtained regarding the processes of life in the animal economy, even when these cannot be subjected to direct experiment. Thus he has thrown considerable light on the phenomena of motion, by applying to their elucidation chemical laws, which analogy led him to expect would come into operation during the exhibition of these phenomena. There are many other processes to which he has not devoted attention, and which seem to be explicable on like principles. One of these—the subject of Sleep—is of great importance in its relations to medical practice, and yet very little is known of its cause, or of the chemical state of the body during its occurrence. Park, in his able Memoir "On the Causes of Sleep and Dreaming," has pointed out the errors of those physiologists who preceded him in investigations on this subject; but he has not succeeded in doing more than establishing that certain physiological states of the body offer inducements to sleep, without showing in what manner these contribute to the production of a quiescent state of the mind. He considers

that the true causes of sleep are, the periodical diminution in the action of the heart, and simultaneous relaxation of the vessels of the brain, by which a slower though fuller circulation of blood through the brain is effected. This merely describes a physiological state of the body, without showing in what manner that state favours the quiescence of the mind. It therefore does not furnish an explanation of sleep, but merely points out the condition of the body which induces the repose of the mind. A more accurate explanation is therefore desirable, in order that we may fully understand the circumstances which predispose to sleep, or occasion wakefulness.

In the present attempt to show what chemistry seems to point out as the probable cause of sleep, and of its concomitant phenomena, I do so more with the object of drawing attention to the subject, than with a view to insist on the perfect accuracy of the chemical explanation. Chemists are too apt to fall into the error of converting the animal body into a laboratory; and therefore it is the duty of the physiologist to watch their steps narrowly, and prevent the evils which may arise from this error. On this account I wish the views here given to be only accredited so far as they stand in unison with the acknowledged experience of medical practice.

The production of animal heat, according to the chemical view of the subject, is due to the union of oxygen with certain constituents of food, or with the tissues already formed. The carnivora depend wholly on the waste of the muscular tissues for the maintenance of the heat of their bodies, for the flesh on which they subsist is destitute of the unazotized organic constituents which are employed in supporting the proper temperature of the herbivora. Liebig has gone far to prove that the oxidation, or waste of tissues in the carnivora, takes place only when the vital powers are employed in the execution of a movement re-

quired by the will—at a time, therefore, when they are not engaged in resisting the encroachments of chemical affinity, represented in the body by the oxygen contained in arterial blood. He has also shown that the waste of the muscular tissues of the herbivora is effected under similar conditions. According to this theory, there cannot be a movement in the body without a corresponding waste (oxygenation) of matter in the organ subjected to motion. The circulation of blood in the body, and the constant conversion of venous into arterial blood, afford an abundant supply of oxygen to replace that expelled from the system in the excretions. These consist mainly of carbonic acid (CO_2) and of urea, which is an amido-carbonic acid $CO, (NH_2)_2$.

Whilst the animal receives a quantity of food sufficient to restore the matter carried off by oxygen, there are exhibited no peculiar phenomena. But when it is deprived of food, as in the case of starvation, the changes of matter which occur in the system are characteristic and worthy of attention. As the oxygen of the blood does not now meet food, with which to unite, it seizes upon the vital tissues themselves, and effects their destruction. The sufferer now becomes rapidly emaciated, and the urine is observed to contain an excessive quantity of the products which result from a waste of the tissues. After this emaciation has proceeded for some time, the substance of the brain begins to yield to the destructive action, and, according to the rapidity of its waste, excited action or delirious paroxysms ensue. Then the heart becomes enfeebled, the blood flows less quickly than it did before, the delirium subsides, and the patient dies from exhaustion. The phenomena observed in fever, and produced, according to chemists, by the entrance into the body of a substance already in a state of oxidation, either as a specific contagion, by the intrusion of certain specific living cells or microphytes, or as malarious matter, are precisely of a similar character. The point in

its progress, bearing upon our present subject, is the increase of force in the involuntary organs, which in time passes over to the voluntary organs, and to the brain, producing, as in the former case, delirious paroxysms.

The great distinction between animal and vegetable life is volition: vegetables, not being possessed of volition, are constantly engaged in increasing their fabric; and, therefore, when volition ceases in the animal, it is aptly said to have a *vegetative* life, for the vital powers are employed in increasing the mass of the body. Sleep is the time when an animal becomes assimilated to a vegetable. Physiologists have shown that the two most marked points during sleep are diminished respiration and decreased circulation. They are agreed that, towards the evening, or at the lapse of a certain number of hours of work, the involuntary organs, the heart and lungs, lose their wonted activity, and suffer a periodical diminution of action. Blumenbach describes the case of a patient trepanned, in whom the brain was observed to sink during sleep and enlarge on waking, obviously arising from the circulation being diminished in the former state and increased in the latter. The consequence of this diminution is, that less oxygen is taken into the system. Hence the proportion of venous blood is increased, and the waste caused by arterial blood diminished. The skull, being a close cavity, must contain a larger proportion of venous, if there be a diminution of arterial blood in the body. It is the latter alone which can cause the waste of the brain, for venous blood has already parted with its oxygen to materials met with in its course. [Modern researches have conclusively proved that during sleep the brain is in a condition of anæmia, or partially bloodless state. The temperature of the body falls from half a degree to even two degrees in profound sleep. The pulse is less frequent, the respiratory movements fewer in number and almost wholly thoracic. Mosso, in 1881, showed, by the

graphic method, that there is a lessened amount of blood in the brain and an increased amount in the extremities during sleep. Helmholtz found a large diminution of oxidation during sleep, for while the amount of heat or "calorics" was only 40 per hour, it increased to 112 during wakefulness. All the recent researches have been confirmatory of the views given in this address.]

Matter in a state of inertia can never manifest the existence of a power. Its motion alone shows that some power is in operation. If the portion of matter used as the organ of manifestation be placed in such a condition as to render that manifestation impossible, there is no evidence to the external world that power was exerted. It has been perfectly demonstrated, that every manifestation of power in the voluntary organs is accompanied by a change in the matter of which they consist. The changed matter being now unfit for vital structures is separated from the body. Muller and other eminent physiologists are of opinion that the same change takes place in the brain, the organ of the mind. In fact, the contrary opinion involves such violation of analogy, that its adoption, unless founded on the strongest grounds, is inadmissible. We look upon a spot attentively; it gradually waxes dimmer, until it finally disappears. We think upon a particular subject; in time our thoughts are less clear, soon they become strangely confused, and we are obliged to give up the attempt at concentration, by thinking on a subject quite different from that which first engaged our thoughts. This of course implies that the organs of manifestation have become in part destroyed, and that the mind cannot manifest itself to the world, until the impaired organs have attained their proper integrity; for it cannot be conceived that the mind, disconnected with matter, could suffer exhaustion. This involves, it is true, the idea that different parts of the brain are employed in different manifestations, but we know that

as far as sensation and intellect are concerned, this is the case, and probability indicates a still more minute division. If, therefore, the brain suffer changes, as do the other organs of the body, by their exercise, there is as much necessity for repose in the action of the brain, as there is for a vegetative state of existence to reinstate in their full integrity the organs of volition. Hence the necessity for that quiescent state of the mind known as sleep, when its manifestations cease. The waste of cerebral substance could only have been occasioned by oxygen, which is the only ultimate cause of waste, as far as we are aware, in the animal economy. A deficiency in its supply would therefore retard waste, and allow vitality to remodel its impaired structures.

Such, then, is the state into which the body is thrown by the periodical diminution in the action of the heart and lungs. The less rapidly that the heart beats, the less rapidly can the blood be aerated, and the oxygen-bearing fluid can be supplied to the brain. The slower that the lungs act, the slower must oxygen enter the system to supply the diminished circulation. And as the brain in sleep is not in a state in which it can change, from a deficiency in the supply of oxygen, the consequence is (if it be admitted that the manifestation of thought and sensation is accompanied by changes in the material substance of the brain), that the manifestations of the mind are prevented, and it becomes no longer apparent to the external world.

This, then, is SLEEP. If the theory be correct, it must be able to explain the various circumstances which occasion or act as predisposing causes to the production of this state, and if it fail in the explanation of any of these, then is the theory imperfect; but if it explain more of them than the other theories usually received, such as those of Cullen, Blumenbach, Park, and others, it deserves to be considered as a nearer approximation to the truth,

and the cases which it fails to comprehend may be included as our knowledge advances.

The first point demanding consideration is, how it happens that a recumbent posture is favourable to sleep. Park justly ascribes this to the diminished pressure of the blood on the heart. The weight of the column of blood from the head to the heart, estimated by Hales as equal in force to five pounds, is removed, and thus its distending force is diminished. The heart now relaxes, and the blood, therefore, is sent less quickly through the system. Having, by the horizontal posture assumed, acquired a retarded flow, the blood now comes less rapidly in contact with the organs of respiration, on which the same posture has produced a diminished action, and thus the quantity of arterial blood in the body becomes diminished. Though all the vessels in the brain may remain as full as they did before, yet, by the deficient supply of oxygen, or, in other words, of arterial blood, and by the retarded circulation of that which does exist in the cavity of the skull, the causes of waste are diminished, and, therefore, according to the theory, sleep is produced. For the same reason, sleep ensues when the aorta of an animal is tied, or when arterial blood is removed in large quantity from the body by excessive bleeding. Bichat has shown that when venous blood is withdrawn from a vein and projected into an artery, sleep ensues, amounting to asphyxia, or even to death. The later researches of Dr. Kay-Shuttleworth have proved that part of the results obtained by Bichat might have been due to an increased pressure on the brain. Increased pressure in a close cavity like the skull means the expulsion of arterial blood from the brain, the very condition for coma. The action of anæsthetics, like ether and chloroform, in producing sleep, may possibly be owing to their power of arresting oxidation, just as the vapour of turpentine stops the oxidation of phosphorus in air. A diffused vapour in

the brain which arrests oxidation must, according to the theory, produce sleep.

Anything which removes the oxygen from the blood will in the same manner cause sleep. This is particularly apparent in the debauch of a drunkard. The drunkard takes alcoholic liquors with the production of two opposite effects. At first his heart beats rapidly, the blood flows more quickly, and he enters into that stage of fever which I described at the outset of the paper, in which the rapidity of circulation causes such an enormous supply of oxygen to the brain that its substance wastes so rapidly as to become unfitted for the seat of the intellect, and delirium ensues. But even while this delirium is at its height, the vapour of the alcohol is penetrating by diffusion every part of his body. Its hydrogen and its carbon are converting arterial blood into venous by depriving the former of oxygen, which is its essential characteristic. The delirium now subsides; but the alcohol carries on its work of depriving the blood of oxygen, and the latter, now not reaching the brain in quantity as it did before, prevents change in its substance, and the drunkard falls down in deep stupor or sleep. To restore him from this state, we withdraw the combustible fluid from the stomach by means of the stomach-pump, and by ammonia and other stimulants endeavour to excite respiration and circulation, in order that the alcohol may be more speedily consumed.

The action of alcohol differs from that of opium or narcotics, because the permanent effect of the latter, whatever the first transitory effect may be, is to diminish the action of the heart and lungs, and therefore the sleep thus occasioned is brought about by causes exactly similar to those which in the natural state of health produce ordinary sleep.

The tendency to sleep in different animals is in inverse proportion to the amount of oxygen consumed by them, and

to the amount of carbonic acid produced. Thus, reptiles and the naked amphibia produce, relative to their weight, according to the experiments of Müller, one-tenth the amount of carbonic acid evolved by mammalia, and one-nineteenth that of birds. We have no numbers to express the tendency to sleep of these animals, but it is known that reptiles are peculiarly liable to be in a state of torpor or sleep; while birds are, on the contrary, wakeful animals. A reptile, such as a frog, will exist in a state of torpor for twelve hours in an atmosphere of pure hydrogen gas, while birds die in the same number of seconds with the ordinary symptoms of asphyxia. Hydrogen gas, when respired with air, gives a tendency to sleep, as shown by the experiments of Allan and Pepys, probably owing to the conversion of arterial into venous blood, as in the case of alcohol. The same circumstance of a diminished supply of oxygen to the blood, which induces sleep in reptiles, acts also in different mammalia in the promotion of this state, according to the relative size of their lungs. Possibly, the tendency to sleep or wakefulness in different men may be due to the same cause.

The only explanation which I have seen of the tendency to sleep after a heavy and excessive dinner is that first promulgated, I believe, by Macnish, who ascribes it to the drafting away of a large amount of sensorial or nervous power from the brain to complete the digestion of the excess of food in the stomach. This implies the necessity for considering the first act of digestion as an act connected with the nervous centres, of which, to say the least, there are great doubts. The drafting of sensorial power—that is, as I take it, of power connected with the operation of the mind; for, if not, its removal could not favour the quiescence of the latter—is a mode of explanation which must be considered very improbable. I am not aware that an inducement to sleep is in general experienced when a small quantity of an indigestible food is

taken into the stomach; and yet this ought to be the case, according to the view of Macnish. The tendency to sleep is occasioned when the stomach is too much distended by an excess of food (or if it do occur with a small quantity of an indigestible aliment, then there is an excessive flow of arterial blood to the stomach to assist in the more rapid oxidation of its coat, to assist in the formation of the peculiar substance termed pepsin). The consequence of this distension is, that the diaphragm which separates the intestines from the heart and lungs is pushed upwards against the latter, encroaching upon the space which ought to be occupied by them, thus preventing their free play, or, in other words, depriving the blood of its proper supply of oxygen, and therefore producing sleep. A person subject to sleep after dinner experiences a sensation of cold, obviously arising from the diminished oxidation in his body. If this cold continue, sleep is prevented; because it excites—as cold generally does—the respiratory organs to greater activity, and this activity acts as an antagonist to sleep, or in fact neutralises the effects arising from the pressure of the diaphragm against the lungs. Hence it is that such persons draw their seats towards the fire. The warmth of the fire prevents the increased action of the lungs which are excited to activity by a diminution in the temperature of the body, and as they now remain in quiescence sleep ensues. Hence, also, a gentle walk after dinner removes the tendency to sleep by accelerating the play of the lungs, which now, by their increased action, introduce sufficient oxygen into the system to prevent sleep. It is also possible that the increased flow of arterial blood to the stomach after a heavy meal may cause a tendency to sleep by withdrawing a corresponding quantity from the brain. Insomnia is sometimes relieved by putting the feet into hot water, which, by withdrawing the blood from the brain, favours sleep. The effect occasioned by the pressure of

the diaphragm on the lungs until the distension has ceased, is analogous to the more permanent effects produced in fat individuals. It is well known that very fat people are peculiarly prone to sleep. The fat accumulates round the viscera, pushes up the diaphragm, and lodging around the heart and edges of the lungs, the latter by all these causes are compelled to play in smaller space, and soon become permanently contracted. Hence, any cause which occasions diminished respiration in such an individual will cause him to fall asleep, by diminishing further the supply of oxygen to the system. The mere diminution in the action of the lungs produced by sitting often occasions sleep in such persons. In their case, the further protrusion of the diaphragm after meals almost invariably produces sleep. This is more marked in animals fattened for the butcher. Pigs in the last stage of fattening exhibit this disposition in a marked manner. After distending their stomachs with food, they give a few ineffectual attempts at an active respiration, and fall into deep sleep. The cause is the same as that first stated—namely, the pressure of the diaphragm against the lungs, which prevents a proper supply of oxygen from entering the system. Macnish was not wrong in his observation that the sensorial power became diminished in the brain after a heavy dinner; but he mistook the effect for the cause, when he attributed the tendency to sleep to the abstraction of this power. The diminution of the quantity of arterial blood in the cavity of the skull appears to be the true cause of sleep in this case: and the decrease of sensorial power is a consequence, but not the cause, of the sleep. It cannot be considered that the absence of a disposition to sleep in some kinds of dropsy, in which the diaphragm is pushed against the lungs, forms a decided objection to the view given of the tendency to sleep after dinner; because the contraction of the lungs being gradual, nature suits itself

to the circumstances by exciting a more rapid respiration. Besides, the results occurring in the diseased state ought not to be considered strictly parallel to those we would expect if the body were in health.

Perhaps I might venture to throw out this view as explanatory of the winter sleep of hibernating animals. In summer these animals accumulate fat in their bodies; probably from the very fact of the smallness of their lungs, which prevents the entrance of a sufficient supply of oxygen to convert the unazotised portion of their food into carbonic acid and water. This fat, accumulating around the caul and loins, pushes forward the diaphragm against the lungs. The fat also gathers round the edges of the heart and lungs, and still further diminishes the space in which the latter ought to play. Thus respiration is greatly retarded, in consequence of which the animal falls asleep. This explanation accords with the interesting experiments of Saissy, who has shown that hibernating animals decompose most air when they are in a state of greatest activity, that they respire less during autumn as their fat accumulates, and that the respiration becomes extremely feeble at the commencement of their winter sleep, and ceases altogether when that sleep becomes profound. Spallanzani has confirmed this fact, showing that there must be a cutaneous respiration, for a small amount of carbonic acid is evolved, although the lungs cease to act. During the long-continued sleep of the hibernating animals, the lungs play slowly; in fact, several minutes often elapse between each respiration, and the diminished state of oxidation is proved by the reduced temperature of their bodies, which is generally not higher than four degrees above that of the surrounding medium. In this state they are like lamps slowly burning, their fat being the oil, and the lungs the wick of the lamp. It is true that cold is favourable to the production of hibernation, and this is not in opposition to the theory; but

Berthold has shown that hibernation takes place in a warm as well as in a cold atmosphere. If our view be correct, very fat animals should show a similar disposition to sleep, and it is known that a pig in its last stage of fattening is rarely awake. Instances have occurred in which pigs, being placed in a favourable condition, have actually proved their capability of being in a state of hibernation. Thus Martell, in the "Linnæan Transactions," describes the case of a fat pig overwhelmed with a slip of earth, which lived 160 days without food, and was found to have diminished in weight in that time more than 120 pounds, an instance quite analogous to the state of hibernation.

It is well known that intense cold is a powerful inducement to sleep. This effect is partly mechanical. The vessels containing blood become contracted; the blood itself becomes more dense, and flows more sluggishly; and consequently the brain, from the operation of both these causes, is less freely supplied with arterial blood. The theory, therefore, explains the result. This is the case only with extreme cold, for a slightly reduced temperature, instead of promoting, often retards sleep. But here also the theory is true to itself, for slight cold is known to increase the rapidity of respiration, and therefore causes an increased supply of oxygen to the system. Slight cold cannot act in this way so easily in the case of hibernating animals as in others, because the accumulation of fat, and enlargement of the glands in the chest and neck, press upon the respiratory nerves and prevent their proper action.

If, then, it be true, that before the mind can manifest itself to the external world, its organ, the brain, must be in the position to unite with oxygen, anything which tends to withdraw it from that position must cause an impairment of the faculties, even if the cause do not operate with sufficient intensity to produce sleep. This is very apparent in the cold stage of ague, when the blood circulates slowly

through the body. In fever, on the other hand, when the blood rushes in a torrent through the system, the mind becomes acutely sensible to every perception. In fever also we find little disposition to sleep; and when this does occur, it is restless and disordered, accompanied by troubled dreams. The chemistry of this disease affords us an instructive lesson with regard to phenomena resulting in the case of health. There are two states into which organic matter passes—DECAY, being the change which ensues when a large supply of oxygen is present, and when the small living organisms which exercise so much influence upon it are able to appropriate this element; PUTREFACTION, when that supply is deficient. During the waking state in fever, decay or eremacausis proceeds rapidly, and delirium, the consequence of this state, appears when the heart beats quickly and the lungs play strongly; in other words, when the greatest supply of arterial blood is sent through the system. But during night, when the oxygen-bearing blood is decreased in quantity by diminished respiration—when oxygen is therefore not present in quantity sufficient to combine with the changing matter—then it passes over into putrefaction, indicated by the blue spots which then appear. This view of fever, either as exhibited in fevers of the typhoid type, or those occurring in malignant forms of disease, is not unimportant. If the appearance of petechiæ during sleep be, as I suppose, an indication that the body has passed over from the chemical state of eremacausis to that of putrefaction, from a deficiency in the supply of oxygen, then the means for the prevention of these states are very different, and the practice in the treatment might be made to suit the periodicity of the return. I throw this out as a mere suggestion for further inquiry. But there are numerous points in support of this view. It is only in the absence of increased action that we observe the ammoniacal nature of the excretions, or the peculiar odour of

the breath which indicates a state of change, the very reverse of that of eremacausis. In this state, even on the old system of treatment, bleeding was not resorted to, but, on the contrary, stimulants were employed to cause increased circulation; for experience pointed out that the change thus begun is that which continues when vitality has left the body.

This case affords a clue not only to the explanation of chronic wakefulness, but also to wakefulness under ordinary circumstances. Some organic matter, in a state of decay, or, perhaps, some living organism capable of growth and multiplication, has entered the body, and has thrown the blood into a state of change. To prevent any dispute as to the kind of matter, let us take the case of sympathetic fever, or of an allied disease. A patient enters the hospital with a fractured bone, the case goes on favourably, nothing is at first observed but local irritation; then it may assume a malignant form—pus, obviously by its odour in a state of change, is observed to collect. Then some of this is absorbed into the blood (for Gulliver states that he has found it there), and communicates to that fluid the same state of change which we now know is owing to the multiplication of living organisms. Then fever, called sympathetic, ensues; but if it be "sympathy," it is sympathy exerted by one matter upon another, as a decaying orange excites decay in a fresh orange. This fever, be it observed, does not arise usually when an abscess is unbroken. It is generally excited when the pus has come in contact with air, and has received the living germs. We try to prevent this by means of poultices, these poultices being made of materials which will of themselves unite with oxygen, and thus prevent it acting on the pus. Occasionally poultices are used made of yeast and flour, as in the cataplasma fermenti of the London Pharmacopœia, the object being to surround the pus with an atmosphere of carbonic acid, and thus prevent

the access of oxygen. The most favourite poultice in use is that made with linseed, which from its oil and mucilage possesses a powerful affinity for oxygen. Very probably the oxidation in these cases favours the growth of the microphytes which enter the blood and which require for their growth oxygen. The state of change, being once excited goes on, and cannot be arrested without vigorous measures; sometimes not at all until death ensues, from the combined effects of decay and putrefaction following each other as the oxygen is sufficient or deficient. The point to be observed is this, that the change in the blood, once begun, is with difficulty arrested; the disposition to oxygenise is communicated, and if there be oxygen sufficient, matter will be oxidised. Then, to apply this to our subject, the brain becomes excited by intense thought, by the exercise of imagination, by exciting scenes of amusement, or by whatever cause it may be. The mind, being called into full exercise, must in its manifestations cause a change of matter in the organ in which it resides. In this case the change of matter is excessive, and the tendency to oxidation is communicated to the part of the brain contiguous to that in a state of change. This also becomes oxidised, and the cerebral substance does not get into that state which favours the quiescent state of the mind known as sleep. The student, after severe and exciting study, is familiar with this state of wakefulness. If his studies have been such as to demand the exercise of his reason, on retiring to rest he endeavours to force his attention into subjects the reverse of the former, generally those of imagination. In other words, he endeavours to withdraw the mind from manifesting itself through that portion of matter which is thrown into a state of change, and by so doing it gradually resumes a state of tranquillity, and sleep then ensues. But if, by excessive or diseased action, such as in insanity, the inflamed (oxygenising) matter cannot be made to yield its tendency to change,

then chronic wakefulness ensues, so often seen in the case of the insane. To reduce this state, we endeavour to extinguish the eremacausis, by lowering the temperature either by cold ablution or by ice, or by administering opium to diminish respiration and circulation. As soon as the change is arrested in the substance of the brain (what physicians call "inflammation," which chemists interpret "union with oxygen"), the brain is placed in a state unfit for being the organ of manifestation, and sleep ensues. The wakefulness of patients afflicted with delirium tremens is obviously connected with the amount of arterial blood and consequent inflammation and oxygenation of the brain; and as disease is merely a disturbance of the equilibrium in the causes of waste and those of supply, any magnified exhibition of a phenomenon occurring in disease must have its reduced analogue in the ordinary state of health. Wakefulness is that analogue, being a tendency to excessive change in particular parts of the brain, induced, it is true, not primarily by the change, but by the activity of the mind itself requiring that change to aid in its manifestation. Follow the analogy, and we come to dreaming, which, apart from its metaphysical aspect, is a physiological phenomenon, so far as concerns the state of the matter of the brain during its occurrence. In fever and insanity we attempt to reduce the keen perceptions or delirium by the exhibition of remedies calculated to diminish the waste of matter in the brain. Blood is sometimes withdrawn from the system for the purpose of diminishing the number of the carriers of oxygen. Narcotics are administered in order to decrease the number of respirations, and to diminish circulation. In extreme cases, large doses of brandy or other alcoholic liquors are exhibited, for the combined purpose of depriving the blood of oxygen and of arresting putrefaction.

By all these acts it is admitted that the excessive waste

or oxygenation of the substance of the brain renders it unfitted for the proper action of the mind. It is admitted that the rapid change of matter prevents the brain attaining that state which favours the quiescence of the mind. How it does so we do not know, and perhaps never shall. But these are established facts, the foundation of medical and physiological practice, and therefore cannot be denied. And if this be admitted with regard to the whole surface of the brain, may it not be so of a part? Combe tells us of a patient who was afflicted with an unnatural increase of a feeling of the mind, but that by applying ice to a particular part of the head which was inflamed, the feeling subsided to its natural tone. Dreaming, then, might be considered (this I throw out as a mere speculation) to be a disturbance between the causes of waste and of supply in a particular part of the brain. I mean that if—to use the language of phrenologists without necessarily assenting to their doctrines—the organ of Wonder, from some cause or another, be thrown into a state of oxidation during sleep, that part of the brain would be thrown out of the condition which favours the quiescent state of the mind. Wonder would therefore manifest itself to the external world without being guided by the reasoning powers or judgment, which are in quiescence or sleep. Thus it would revel in all the absurd phantasies to which that feeling of the mind gives rise. I have selected this phrenological organ as a mere example of my meaning, without wishing to insist upon the division of organs as a necessary part of the speculation. If those parts of the brain used as the organs of manifestation for judgment were brought into play at the same time as Wonder, the dream would be more coherent, and, as soon as the change took place to such an extent as to throw the brain into that state which did not favour the quiescence of the mind, then waking would ensue. Hence, according to this speculation, dreaming is a state of wakefulness of a

portion of the mind manifested through particular parts of the brain, while other functions of the mind, manifested through other parts of the brain, are still asleep, and therefore not in a condition, by comparison and reflection, to modify those awake. It is probable that during dreaming there is more arterialised blood in the cavity of the head than during sleep without dreaming, a circumstance indicated by the red flushed appearance of the face during dreams. In some experiments with trepanned dogs, the brain, which was pale during sleep, became flushed in parts during dreams. The speculation is also supported by the class of persons subject to dreaming. A phlegmatic person, whose heart beats slowly and whose lungs play slowly, rarely dreams. A fat person, with a diaphragm well pushed up against his lungs, rarely dreams. The greatest dreamer is the man of nervous temperament, whose heart and lungs do not play with all the steadfastness of the pendulum of a clock, but are fitful in their action. For the same reason, in fever, the quickly-circulating blood, sometimes propelled more rapidly than at others, is apt to cause this state of wakefulness in particular parts of the brain, by throwing them into a state such as does not favour the quiescence of the mind.

It may be objected to the view of sleep here given, that if it were owing to a diminished state of oxidation in the brain, the respiration of pure oxygen ought to retard sleep, whereas, on the contrary, it is observed to render the animal exposed to it comatose, and death ensues after the animal has remained for some time in a state of deep stupor. Yet both the blood in the veins and arteries was found by Broughton to be very florid, and everything indicates a high state of oxidation. Christison and other toxicologists ascribe the death to an increased oxidation or hyper-arterialisation of the blood. The phenomena, therefore, seem in direct opposition to our theory of sleep. Let us

consider the case closely. Arterial blood differs from venous in the state of oxidation of constituents containing iron. The oxidised ingredient parts with its oxygen to the tissues, and converts the matter acted upon into carbonic acid and water. The carbonic acid in a state of combination and solution with a substance containing iron in a low state of oxidation is carried by the venous blood to the lungs, where it becomes oxidised, and the carbonic acid evolved. Now, when an animal breathes oxygen, even the venous blood is arterialised, or, in other words, there is no protoxide of iron left in the system. But, owing to the excess of oxygen gas, there must be a rapid waste of the tissues, and the formation of a large quantity of carbonic acid gas, which has now no iron in a state to carry it to the lungs. It therefore accumulates in the system, and the animal becomes comatose and dies, not on account of *oxygen*, but of *carbonic acid* which has no means of escape. It has been remarked that there is comparatively little carbonic acid evolved in poisoning by oxygen, for the atmosphere in which the animal dies causes a blown-out taper to burst into flame. The heart after the death of the animal is found to beat rapidly, and shows the excited state into which the body was thrown by oxygen, until the accumulating carbonic acid produced the peculiar effects for which it is remarkable. Thus, this simple explanation, while it vindicates the truth of the theory, affords an explanation of the cause of poisoning by oxygen, which toxicologists have always considered as most incomprehensible and singular. The effects of nitrous oxide on the system are very similar to those of oxygen, and are obviously due to the same cause. Broughton found that even the venous blood had become arterialised when an animal was made to respire this gas.

The attentive study of the peculiar condition of matter in the various states in which the mind manifests itself, or remains unmanifested to the external world, is of great im-

portance in the treatment of disease. To take the case of apoplexy and its allied diseases. I do not allude to apoplexy occasioned by the rupture of an apoplectic sac, but that form in which it arises from the turgid state of blood-vessels in the brain, or in the more rare form of what is termed "simple apoplexy" by Dr. Abercrombie. The state in which the brain is placed in this disease seems to be merely an increased state of the condition in ordinary sleep. The congestion or turgid state of the venous vessels necessarily implies a diminished amount of blood in the arteries; for the skull, being a close cavity, must always contain the same amount of fluid; and on this account, if the quantity of venous blood be increased, that of arterial blood must be diminished. Hence, although the use of the lancet may awaken the patient from deep stupor, by removing the deoxidised blood which may have accumulated in the brain by the lesion of a vessel or by some irregularity in the action of the heart, yet it becomes a question whether the removal of blood, by diminishing the number of carriers of oxygen to the brain, may not cause a tendency to relapse when the temporary obstruction shall have been removed. All I mean by this is, that if we admit the cause of sleep to be a diminished supply of oxygen to the brain, we must admit certain forms of disease, such as congestive apoplexy, syncope, perhaps even catalepsy, to be due to the increased operation of the same cause—a circumstance attested by the diminished temperature of the body which results in this class of diseases; if, then, we know the effects to be due to a want of oxygenation of the substance of the brain, we are in a position more completely to regulate our practice in the treatment of such diseases. So, also, in the treatment of wakefulness, dreaming, restlessness, &c., for which the physician is so often called upon to prescribe a remedy, the knowledge of the state of the brain in the state of waking and of sleep, may point out the way to throw it

into the state which favours the activity or quiescence of the mind. Hence a probable explanation of these states is not unimportant in a practical point of view.

It does not necessarily impair the accuracy of such explanation, that many assumptions are taken for granted to explain one part of the phenomenon. When we see a wheel revolved by the ascent and descent of a piston-rod, our explanation of the means by which a perpendicular is converted into a rotatory motion is not rendered valueless because we do not trace it to the means by which the force is generated. We have a right to assume the existence of the necessary force, and from this point alone attempt an explanation. So, also, when I say that the effect of a diminution in the play of the respiratory organs induces sleep, as in the case of intense cold, or that their accelerated action retards sleep, as when the temperature is only slightly depressed ; my conclusion may be perfectly correct, without my being called upon to prove the cause of the diminution in the action in the one case, or its increase in the other, because my attention is confined only to one part of the phenomenon. So, also, if I say that syncope is due to a diminished quantity of arterial blood in the brain, I may be correct as to the proximate cause, without being obliged to show by what means the conducting power of the nerves leading to the involuntary organs has become so impaired as to cause the temporary obstruction of these organs. In describing the chemical state of the body, and the effects produced by this state, the duty of the chemist is only to consider the proximate cause of its production, while the physiologist ought to explain the ultimate causes which predispose the body to enter into that state. I have attempted to explain in certain cases one part of the phenomenon, with the hope that these speculations, if they do not represent the whole truth, may lead other persons to the consideration of the same subject.

ON VACCINATION.

NOTE.—The efforts of anti-vaccinators culminated in a resolution proposed by Mr. Taylor in the House of Commons on 19th June, 1883. There was an impression at the time that the resolution would receive strong support, so the question was left open, and was not made a Government issue, though Sir Charles Dilke, the then President of the Local Government Board, spoke against it in his individual capacity.

THE resolution of my hon. friend the member for Leicester (Mr. Taylor) must be read between the lines as a distinct attack on vaccination, root and branch. When my hon. friend began his agitation, he did not dispute the protective powers of vaccination, though he objected to its compulsory application. That is all that is implied in express terms in his resolution now, but his speech shows it means much more than it expresses. In the mind of my hon. friend vaccination itself is an evil thing, and ought to be extirpated. If he so believe, his resolution ought to express his belief, and he should bring in a Prohibitory Act, as was done in the case of inoculation in 1840.

My hon. friend and the Association with which he acts attack vaccination on two grounds. The first is that it is positively injurious, as a means of introducing disease into the bodies of the vaccinated; and the second is, that it has no protective power against small-pox, which it is supposed to prevent or mitigate. I will deal with these fundamental objections in order.

The assertion that vaccination produces disease was

carefully examined by a Committee of this House in 1871. An active member of that Committee was the hon. member for Leicester (Mr. Taylor), and he will bear me out when I say that we carefully heard the evidence of the anti-vaccinators, and formed a unanimous conclusion upon the evidence which they produced. The allegation that vaccination has been known to produce an offensive disease was practically proved in a few cases in which vaccine lymph had been taken from children suffering from the congenital malady. The possibility of such infection is a terrible fact, but, fortunately, one of the extremest rarity. We had it in evidence that among 151,316 re-vaccinations of soldiers, not one such case had ever been observed, although among them the disease is far from rare. Since 1852 about twenty million infants have been vaccinated in England and Wales, and among these, if there were any large truth in the allegations, not tens but hundreds of cases must have been observed; and yet it is extremely doubtful whether half a dozen central cases of propagation have been reasonably suspected. Though this offensive disease is admittedly only possible by the grossest neglect, certain skin diseases, such as erysipelas and eczema, are alleged to be consequences of vaccination. Admittedly, they may follow the irritation of vaccination, just as they follow the irritation of teething, or as erysipelas frequently appears after a surgical operation. Generally they are instances of *post hoc*, but in a few cases they may be *propter hoc*. Very rarely have they been fatal. That they have been so in very rare instances does not constitute an argument against vaccination. Who would forbid the use of anæsthetics in surgical operations because patients have died from their use? Who would stop the use of narcotics, because to some persons they produce the sleep of death? Who would prevent men drinking water because sometimes polluted water produces typhoid fever? So the Committee of 1871, after hearing

all the evidence tendered against vaccination as the producer of disease, came to the conclusion, in the words of the report, that "there need be no apprehension that vaccination will injure health or communicate any disease." It is true that the hon. member for Leicester (Mr. Taylor) moved the omission of these words, but what were those which he proposed to substitute? They were these—"That some few cases of disease have been communicated by vaccination, but the danger is so infinitesimal in respect to proportion, that, subject to the conditions mentioned above, the Committee do not hesitate to express their conviction of the practically safe character of the operation." I think, then, as the hon. member for Leicester himself, acting as a judge, after hearing the evidence, characterised the subject "as infinitesimal in respect of proportion," I need not trouble the House with any further remarks on this branch of the subject.

I therefore pass to the second postulate of the hon. member—that vaccination is no protection against small-pox. Do not forget what is the nature of the disease against which we seek protection. Sir Thomas Watson describes it in a few words as "the most hideous, loathsome, disfiguring, and probably, except hydrophobia, the most fatal also of the various diseases to which the human body is liable." Against this mutilative and hideous disease we seek to erect barriers by vaccination. Individually, persons, since the time of Jenner, have protected themselves. The amount of protection was thought, even by its discoverer, to be equivalent—but no more than equivalent—to that of an attack of small-pox. In most cases, when men have had measles, scarlatina, or small-pox, they are protected from future attacks, though not invariably, for there are some persons who are subject to more than one attack. In the call of the House of Lords to the Royal College of Physicians to report to Parliament on the whole subject of vaccination,

this liability is stated in express terms. This report is dated 1807, or nine years after Jenner had published his discovery. The words are—"Where small-pox has succeeded vaccination, it has been neither the same in violence nor in the duration of its symptoms, but has, with very few exceptions, been remarkably mild, as if the small-pox had been deprived by the previous vaccine disease of all its usual malignity." That is precisely the state of our knowledge now, so that it is no discovery of the anti-vaccinators that there are cases of post-vaccinal small-pox. In examining the state of vaccination, we must compare the mortality from small-pox with that of the last century. Guy defines an epidemic of small-pox as producing ten per cent. of the total deaths. If this be accepted, there were thirty-two epidemics of small-pox in the eighteenth century, and not one in the nineteenth. The mortality from small-pox last century may be moderately estimated at 3,000 per million of the population annually for the whole country. In London the mortality has always been greater than in the country. In the seventeenth and eighteenth centuries it was certainly not less than 4,000 per million. At the commencement of the present century the mortality was 2,000 per million; and in the ten years ending 1882 it was reduced to 262 in London, though the reduction was much greater in the country at large. For the first forty years of this century vaccination was promoted among the people by charitable agencies, and the mortality had fallen to 600 per million by 1840, or was then only one-fifth the amount of last century. Still, 600 per million is a high rate of mortality, and Parliament began in 1841 to give funds for gratuitous vaccination, so as to spread it more rapidly among the people. This continued till 1853, and the mortality was now 305 per million, so that gratuitous vaccination of the State reduced the mortality to one half. Then, in 1853, Parliament passed an obligatory law, which re-

mained without administrative means of enforcing it till 1871; but still during this period of obligatory vaccination the mortality fell to 223 deaths per million. In that year a law was passed making it compulsory on Boards of Guardians to appoint vaccination officers, and since that time the average mortality has been 156 per million. Every successive step, then, in promoting vaccination has been followed by a great reduction in the rate of mortality. Voluntary efforts reduced the mortality of the last century from 3,000 to 600 per million; gratuitous vaccination by the State reduced it to 302, while obligatory law inefficiently administered reduced it to 223, and the same law under vaccination officers further reduces it to 156.

That is the general result as regards England and Wales. Scotland and Ireland did not get a compulsory law till 1863, or ten years later than England. In the next ten years there were two years of a very heavy epidemic, but still the average mortality of this decade was 214 per million in Scotland and only 108 in Ireland. From 1875 to 1882 the rate in Ireland has been only 72 per million, and is scarcely measurable in Scotland, for it is only 6 per million. My hon. friend the member for Stockport (Mr. Hopwood), both in and out of Parliament, points to the epidemic of 1871-3 in Scotland as a refutation of what he deems a supremely silly remark of mine, that the Vaccination Act in Scotland was sufficient to stamp the disease out of that country. That is exactly what it has done. The words "stamp out" are borrowed from the Cattle Plague Commission, of which I was a member. The Cattle Plague Commission thought that the measures recommended by them were sufficient to stamp out the disease, but not to keep it out, for great epidemics are like huge tidal waves, which may roll over any ordinary embankments. It must be borne in mind that these embankments are never wholly continuous, for the unvaccinated are like holes in them, through which the

flood of disease finds its way. Vaccination is, under ordinary conditions, a sufficient protection; but in the presence of a great epidemic it is overtopped, and small-pox spreads over a country, attacking the unvaccinated and those whose protection has worn out by age. As it increases in volume, the vaccinated too are carried away by it, but vaccination is their life-belt, and they rarely perish. It was so in Scotland in the great epidemic to which I will allude later on in greater detail. When such an epidemic strikes a population, they become terrified, and they rush in crowds to be vaccinated. At that time the compulsory law had existed for eight years in Scotland, and only the infant population had come under its influence. The people of Scotland, not being agitated by Anti-Vaccination Societies, rapidly extended vaccination among themselves, and stamped out the epidemic. Since then small-pox has scarcely existed in that country. For the last few years the total number of deaths have not exceeded ten per annum.

These great reductions in the rate of mortality from small-pox I believe to be due wholly to vaccination; but my hon. friend the member for Leicester attributes them to improved sanitation and to the improved habits of the people. If that were true, this sanitation must equally affect other diseases besides small-pox, and no doubt it does, but to what amount? If we compare the period of gratuitous vaccination with that of efficient compulsory vaccination, the Registrar-General tells us that, among children under five, the small-pox mortality has decreased by 80 per cent., while that from all other diseases has only decreased by 6 per cent. As age advances beyond fifteen years mortality does decrease in other diseases, probably from sanitation, but it increases as regards small-pox, showing how little influence that has as a factor in governing the progress of that disease. The cause of the increased mortality in small-pox at advanced ages is probably that there

are still many unvaccinated, and that among the vaccinated the protective power wears out as age advances. The fact, however, conclusively shows that improved sanitation has little connection with the large reductions in the rate of mortality from small-pox over the whole community.

The results which I have described are the figures of the Registrar-General, and are derived from an examination of long periods, so as to include the epidemic and non-epidemic years. How is it that they sound so differently from the figures given by the mover of the resolution? He startles you with large figures, such as 40,000 deaths in the Metropolis during an epidemic, and he rarely throws them into comparable rates of mortality. He also relies chiefly on the returns of London mortality, and puts on one side the saving of life throughout the country. I intend to meet him on his own ground, and to show that the case for compulsory vaccination is best supported by epidemic periods.

Modern science tends to show that such diseases as small-pox arise from the growth in the blood of minute organisms. Now, like other crops, there are good and bad years for their growth. Just as there are good years for pears, apples, and plums, so there are productive years for small-pox, measles, and scarlatina. In the case of small-pox, these productive years come every fourth or fifth year, and then the crops are full or excessive. There are three varieties of small-pox, which represent themselves in the epidemics. The first is discreet small-pox, where the pustules are separate and distinct, and it is rarely fatal. Then comes the confluent small-pox, where the pustules run together. In this form nearly half, or 50 per cent., of the unvaccinated die. Of the vaccinated when attacked by confluent small-pox 15 per cent. die. Thirdly, comes the black or malignant form, which rarely attacks the vaccinated; but when it does, it proves as fatal to them as

to the unvaccinated, for 95 per cent. of the persons attacked by this form of small-pox die. It rarely visits this country now in an epidemic form, but it did appear in a marked manner in the epidemics of 1871–72, and the London epidemic of 1881.

It was largely seen in the epidemic which devastated France in 1870, and which passed all over Europe in that and the two following years. Just as "Sweating Sickness" followed in the train of the wars of the Red and White Roses, so did malignant small-pox follow the camps of the French and German armies in 1870. Both Powers had about half a million of men in the field, though under very different conditions. Germany was quite prepared for the war, and had its troops under perfect organisation. All its recruits were re-vaccinated. In ordinary times France also encourages the re-vaccination of the recruits, and in the year before the war about 40,000 recruits were so treated. Prussia does it more systematically, and in the same year vaccinated 216,426 of its soldiers. Nevertheless, the Paris garrison in the early part of 1870 had scarcely any small-pox, while 1,000 of the civil population had already died. The recruits who were hurried in from the provinces soon added to the military deaths. Dr. Leon Colin, the Physician-General of the French army, has published a work on the small-pox epidemic during the war. He tells us that the levies hurriedly raised were unvaccinated. I give his own words:—"The different armies raised thus in haste, and placed in the field without time for re-vaccination, were exposed both at their places of gathering and in their marches to the attack of this epidemic;" and the consequence was that during 1870 and 1871 a great number of French soldiers died of the disease, of whom 1,600 died in the garrison in Paris, out of an army of 170,000. The small-pox followed the German camps also, but few of their soldiers died. It was not because they were Germans that

small-pox spared them, for it attacked the city of Berlin in January, 1871, and was nearly as fatal to the civil population there as it was in Paris during the siege. I contend that the German soldiers escaped on account of their re-vaccination. Many hundreds of them were prisoners in Paris during the siege, and only one of them was attacked by a mild form of small-pox. Could a more pronounced experiment on a large scale have been made in regard to the value of vaccination?

This epidemic became pandemic, for it not only devastated Europe, but invaded both North and South America, as well as the South Sea Islands. Before describing its ravages in this country I may as well say how far it influenced our 90.000 re-vaccinated soldiers. It entered our army, as it did this country, in 1871, and lingered in it during 1872, but during those two years it only killed forty-two soldiers. The effects of re-vaccination in our own army and navy have also been decided. It has only been made compulsory in the navy since 1871, the year of the epidemic. In that year and in 1872 there were thirteen deaths from small-pox in the Home Naval Stations, and since then there have been none at all with the exception of one death in 1882. From 1873 to 1884 there were thirty deaths in foreign naval service, of which fourteen occurred in 1879. In the epidemic year of 1871 the ratio of deaths in the English army was 210 per million, and 260 in the navy, the former having had compulsory re-vaccination, the latter only beginning in that year. The ratio of the civil population at corresponding ages was about 1,000. The epidemic of 1871 struck the civil population of England and Wales strongly, and was exceptionally severe in the Metropolis. With the exception of local outbursts in Birmingham, Liverpool, and Salford, the small-pox since 1873 has been very small in all our large towns, except London, where it has lingered, and came as a renewed

outburst in 1877 and 1881. Most of the arguments of the anti-vaccinators are derived from metropolitan small-pox. Thus, in 1880 the total deaths in England and Wales from small-pox were 648, out of which London alone was responsible for 471. The epidemic of 1871–72 was general and severe, but the recent epidemics of 1877 and 1881 have been mainly metropolitan. I mentioned that before vaccination was introduced in last century the deaths from small-pox throughout the country were 3,000 per million over periods embracing epidemic and non-epidemic years, but in the heavy malignant epidemic of 1871–72 the death rate was 928 per million over the whole country. The average death rate from small-pox in the Metropolis before vaccination was 4,000 per million, and in the great epidemic year 1871 it was 2,420 per million. So that even in this exceptionally severe epidemic the death rate was only about one-half of that of average years in last century.

The anti-vaccinators say, Why did it enter into a metropolis, of which at least 95 per cent. of the people are vaccinated? That 5 per cent. means a residue of 200,000 unvaccinated persons, besides all the imperfectly vaccinated, and those in whom the protective effects have worn away by age. Surely that is soil enough for a good harvest of small-pox. While, therefore, other parts of the country seem to have recovered from the great epidemic influence of 1871, London has not yet gained control over the disease. It had practical immunity in 1873, '74, '75, but outbursts came in 1877 and 1881—in the latter year to about one-third of the extent of 1871, but still amounting to 640 per million. That, large as it is, represents only one-fifth of the average mortality of the last century. The other parts of England and Wales during the same year had only a mortality of 100 per million. If we take the five years ending 1884, the difference between the small-pox

mortality in London and in the Provinces is marked, for the ratio per million was 244 for the former, and only 34 for the latter. The anti-vaccinators point to the fact that there were absolutely more cases of small-pox among the vaccinated than among the unvaccinated during the epidemic—a fact which obviously must arise when 95 per cent. of the people are vaccinated.

Looking at the epidemic generally throughout the kingdom, the argument may be put in this way. When the 1871 epidemic went over the country, there was an infant population of more than three millions under five years of age. It consisted of two classes in daily intercourse with each other, though one class (the vaccinated) was thirty or forty times more numerous than the other. They lived intermixed, residing in like houses, eating the same food, and breathing the same epidemic air. In the class which was thirty or forty times the size of the other, 413 deaths occurred; while in the smaller class 1.178 deaths occurred—that is, four deaths occurred in the smaller class for every death which occurred in the class which was thirty or forty times larger. If you convert that into a rate of mortality for each class, you will find that the rate of mortality was from 120 to 160 times greater among the unvaccinated than among the vaccinated children. The only circumstance which differentiated these millions of children was vaccination; and as the incidence of small-pox was so enormously different in its mortality according as the class was or was not vaccinated, the conclusion as to a very large amount of protection in the case of children is irresistible.* If you carry the argument to the general population of all ages, the Registrar-General tells us that in the same number of people the vaccinated give one death and the unvaccinated 44 deaths.

* Since State supervision of vaccination infantile small-pox mortality has sunk from 227 to 21, which, upon a population of 37 millions, means an annual saving of 7,622 small-pox deaths.

The hon. member for Leicester bases his argument also on the fact that the town which he represents, though so badly vaccinated, has had little small-pox, or practically none at all in recent years. That is equally true of well-vaccinated and badly-vaccinated towns throughout the country. In 1872 Leicester was not a badly-vaccinated town, and perhaps my hon. friend might argue that was the reason why it had 313 deaths. Well, I earnestly hope it will not soon come under an epidemic wave, for I can give him an instance of a large town which did neglect vaccination among its people, and of the results which followed when an epidemic struck it. Leipsic was the centre of a most zealous propaganda against vaccination, in which the anti-vaccination associations were powerfully assisted by the press. The result of their agitation was that infantile vaccination had been greatly neglected, and Leipsic was in that happy state which Leicester now rejoices in, of having refused to vaccinate its children. Leipsic had been singularly free from smallpox, as Leicester now is. In 18 years, from 1851 to 1870, it had only 29 deaths from this disease, and the anti-vaccination propaganda pointed to it with triumph. But the pandemic reached this town of 107,000 inhabitants towards the close of 1870, and killed 1,027 of its people, or at the rate of 9,600 per million. The infantile death rate was terrific. There were 23,892 children living under fifteen years of age, and among them were 715 deaths—actually 3 per cent., or at the terrible rate of 30,000 per million. I have given an example and a warning, but I doubt whether the hon. member for Leicester will profit by it. If the hon. member for Leicester cares to know my authority for these statements, I refer him to the accounts of the Leipsic epidemic by the German physicians Wunderlich and Thomas. Many German towns suffered severely in the pandemic, but in 1874 compulsory re-vaccination was established by law, and since then small-pox

scarcely attacks the large cities of Germany, and is almost unknown in the German army.

If I may add to this speech of 1883 the German statistics of 1886, the evidence in favour of compulsory vaccination and of re-vaccination is overwhelming. The ratio of deaths per million of the population from small-pox was only 3·3, and of these two-thirds were on the border provinces of countries having no compulsion. If we compare the mortality in German towns with that of urban populations in other countries, Germany now stands out in strong pre-eminence:—Germany, 4; England, 77; Belgium, 194; Switzerland, 218; Austria, 325 per million. In Germany 40 per cent. of the deaths occur in children under one year, the period fixed for compulsory vaccination. In England our law fixes three months, and there is a lower small-pox mortality among English than among German children.

The Vaccination Acts are not sufficient to resist a great epidemic wave, but they act as a breakwater and lessen its force. In the metropolitan epidemic of 1881 it was found that 90 in every million of the vaccinated died from its effect, but no less than 3,350 per million of the unvaccinated perished. The reason for this is that even when malignant small-pox strikes the vaccinated, it becomes modified or mild in 73 per cent. of the cases, and retains its virulent form in only 27 per cent. But when it strikes the unvaccinated, 97½ per cent. of the cases pass through the virulent form, and only 2½ per cent. become mild. Hence the perils of attack are vastly greater among the unvaccinated than among the vaccinated. An analysis of 10,000 cases in the metropolitan hospitals shows that 45 per cent. of the unvaccinated patients died, and only 15 per cent. of vaccinated patients.

The hon. member for Leicester treats these hospital statistics as wholly incredible, but they are verified by the hospital statistics in our provinces, and also by those of

other countries during the pandemic. He can only deny them by assuming that a huge conspiracy exists among the medical men of all nations for the purpose of injuring mankind at large. A conspiracy has some supposed advantage to be gained by its success. But how can doctors all over the world benefit by keeping doctors poor through making their patients healthy? These statistics of disease correspond in countries which have compulsory laws and in those which have not. Across the Atlantic there is no direct, though much indirect, compulsion, and no motive to falsify statistics of mortality. In America the mortality among the unvaccinated was even greater than in London during the pandemic. In Boston the rate of mortality among the unvaccinated was 50 per cent.; in Philadelphia, 64 per cent.; and in Montreal, 54 per cent.; while the deaths of vaccinated patients ranged between 15 and 17 per cent.

The arguments of anti-vaccinators are so protean that one never knows what they are. When they assert that vaccination is no protection against small-pox, and does not lessen mortality, our reply is conclusive. In the same breath they admit a largely-diminished mortality by vaccination, but say that it does not lessen the sum of human mortality, for when small-pox deaths lessen, other diseases increase; and they seem to invite us to enter a Golden Age, when all of us should take small-pox as of yore in order to protect us against other diseases. They attach no importance to the discoveries of modern science, which clearly point to the fact that each disease is specific in its character, and that as little could you produce bronchitis, scrofula, or consumption, from *vaccine virus* as you could produce a rose from a cauliflower, or a mastiff from a guinea-pig. That other diseases may produce a greater number of deaths when devastating small-pox is subdued is as certain as the mortality of man, for if he does not die of one thing he will die of another. An expensive return was made to the House

in 1877, giving the deaths of fifteen diseases before and after vaccination. This return shows that some diseases had an increased and some a lessened mortality; but for their purpose they are ludicrously perplexing. Thus, the main increase was in bronchitis, which has about the same relation to vaccination as the Goodwin Sands have to Tenterden Steeple. If they had any relation, will the hon. member for Leicester tell me why that unvaccinated town has such an excessive amount of infantile diarrhœa? That is pronounced by his followers to be a "post-vaccinal disease." How does it happen that when vaccination in Leicester is at low tide, diarrhœa is at flood tide? Erysipelas, scrofula, and convulsions, which are the pet outcomes of vaccination, had actually decreased upon the whole population. Syphilis, indeed, had largely increased, but the Registrar-General has since told us that the classification was different in the first and second periods, and could not be compared. While, therefore, fully admitting that man is mortal, and that he must die of something, I believe, both in logic and in fact, that the conclusions drawn from this 1877 return are just as worthy as if I asked the House to accept as a conclusion that the few deaths of small-pox in Ireland in 1882 were the causes of the increased number of Fenian assassinations in that year.

Surely the history of this last epidemic tells us most clearly that the foe is at our doors, stronger and more hostile than it has ever been during this century. It is the same form of small-pox which killed Queen Mary, wife of William III., described by Macaulay in these terms—"The plague had visited our shores only once or twice within living memory, but the small-pox was always present, filling the churchyard with corpses, leaving on those whose lives it spared the hideous traces of its power, turning the babe into a changeling, at which its mother shuddered, and making the eyes and cheeks of the betrothed maiden

objects of horror to the lover." When he thus described small-pox, every one was as subject to it as we now are to measles, and happy were the survivors who passed through with unimpaired health or without disfigurement. Now, thanks to vaccination, though the malignity of the disease at the present time is as great as then, we have, to a large extent, protected the population by compulsory laws; and it is this protection which it is sought to remove by a resolution, concealed in its purpose, but obvious in its design. I fear that I have wearied the House by statistical results, but they could not be avoided. To my mind, they prove conclusively that small-pox is now as malignant and loathsome a disease as it was 200 years ago, and that it is only kept at bay by the protective influence of vaccination. This resolution, if adopted, would bring us back to the year 1840, by which time charity vaccination had reduced the mortality of 3,000 per million to 600 per million, for I presume it would be followed up by another resolution preventing State funds being used for optional vaccination. Compulsory vaccination has reduced the mortality, including epidemic periods, to one-fourth this amount; but we are to renounce this advantage, because there are certain parents who think the law is unjust and oppressive. Even in Leicester, which wars against vaccination in the interests of human liberty, persons suffering from small-pox are compulsorily taken from their homes and are isolated in a special hospital.

We have many laws interfering with personal liberty. We restrict hours of labour to working men, although many of them think our restriction unjust. We punish the rash traveller who jumps into a train in motion, although it would injure no one but himself. If small-pox affected an adult individual only, his right to take it could scarcely, however, be disputed. We do not punish a man for burning down his own isolated mansion if no one is injured but himself; though we do punish him if he risk

a neighbour's property by his act. Every case of small-pox is a new centre of contagion. A man may exercise his own personal taste for any disease which he chooses, provided he does not injure his neighbours by his idiosyncrasy. When he produces omissional infanticide of his own and his neighbours' children by neglect of duty the State may intervene to protect the young population from a fatal and mutilative disease. This disease is just as fatal and hideous as it was in the last century, but it has been controlled by wise and beneficent laws.

VIVISECTION.

Note.—On the 4th of April, 1883, Mr. Reid moved the Second Reading of a Bill for the Total Suppression of Scientific Experiments upon Animals. On that occasion the following speech was made:—

The Bill for the abolition of vivisection not only deals with vivisection in the abstract, but it seeks to repeal the Act passed in 1876 for so regulating vivisection as to produce either no suffering, or the minimum amount of suffering, in animals experimented upon. My hon. friend the member for Hereford (Mr. Reid) proposes to abolish all experiments on vertebrate animals for the purposes of physiology, medicine, or science. The experiments prohibited are not confined to painful ones. Under the plain interpretation of this Bill, a man could not stroke the back of a cat to show a student that electricity was developed without committing a crime. The Bill not only repeals the regulating Act of 1876, but it renders illegal all experiments on animals made for the purposes of physiology, medicine, and science, even if they are wholly innocent and painless. A physiologist, after this Bill becomes law, could not put the web of a living frog under a microscope to show the circulation of the blood.

The House is familiar with the nature of the Act which it is proposed to repeal. It provides that all painful experiments, with the rarest exceptions, must be made when the animals are unconscious under anæsthetics. As a matter of fact, only 1 per cent. of all the experiments made under the Act is as painful as a surgical operation. Of the 300 experiments made last year, only ten were attended with

real pain. The Reports of the Government Inspector for Great Britain, Mr. Busk, and of the Inspector for Ireland, Dr. Stokes, are conclusive on this point. The question is not only whether vivisection, in the abstract, may or may not be right, but whether a regulating Act, which was passed in the year 1876, and which the Government Inspectors assure us works well, and enforces the utmost possible diminution of pain, is to be repealed.

The hon. member for Hereford, to prove that experiments were cruel, cited experiments made before the regulating Act was passed. He described, in terms which, to those unacquainted with physiology, appear horrible, some experiments made on the brains of cats and monkeys by Dr. Ferrier. But he did not explain that the animals on which these experiments were made were wholly unconscious and not susceptible to pain, both in regard to Dr. Ferrier, and also as to experiments made by Professor Rutherford. Even if they had not been under anæsthetics the brain is not a sensitive material, and experiments may be made upon it without pain. This is fully proved in the evidence before the Royal Commission. With these exceptions, the hon. member for Hereford, and the societies which back his efforts to prevent vivisection, chiefly rely on cases of alleged foreign cruelties, although such are impossible under the present law in England, and are now, as they have been at all times, repugnant to the spirit of the English physiologists. That some of the old experiments, made before anæsthesia was discovered, were carried on in France and other foreign countries, with an indifference to animal suffering that was truly horrible, I entirely admit. That they are still carried on in foreign countries without due regard to the use of anæsthetics, is, I fear, only too true, although to a much less extent than formerly. We are not called upon to legislate for foreign countries: we are asked to repeal an Act which has worked well in England, and to

substitute for it another Act, which prohibits all physiological experiments in this country. The evidence is conclusive that English physiologists have always been remarkable for the careful and humane consideration with which such experiments have been made. The hon. member for Hereford does not care for proofs that experiments on animals have been carefully and humanely practised in England. His Bill proposes to abolish them altogether as being opposed to the moral law. I at once make the admission that I am bound to traverse this argument, and not to shelter myself under the fact that he is attacking a mere microscopical point in the field of animal suffering. It is no sound argument against his Bill to say that, because only 10 out of the 300 animals experimented on last year suffered considerable pain, therefore it is right to continue such experiments. The real question is, whether there is a justification for sacrificing or inflicting suffering on any animals with a view to benefit man. You do not doubt this in the case of noxious animals. Last year, in India, we hunted down, without mercy, 6,000 tigers and leopards, besides many wolves, and we paid for killing 300,000 snakes. And what was our justification? It consisted in the fact that they had killed more than 20,000 of the natives of India.

The justification is that man's duty to man is greater than man's duty to beasts.

The benefit to man is, in fact, our only justification for a vast amount of pain which we are constantly inflicting on animals during their lives. How otherwise can the farmer justify the cruel mutilation of oxen, sheep, or swine, to improve their condition for food, or of horses, to fit them for labour? How otherwise could we justify the cruel and continued punishment of animals when we employ them in labour? If I thought that a comparative argument as to cruelty had much force, I could allude to the continued

sufferings of the horses, mules, and camels in the Afghan and Egyptian wars, in terms which would be too horrible for this House to listen to. Even in the relation of man to man, how, otherwise than by a common or national benefit, could we justify the sacrifice of whole battalions in assaulting fortified positions? Or how could we justify the frightful suffering which a surgeon inflicts when he excises a joint or cuts out a huge tumour? How otherwise could you justify a parent when he corrects a child, or the State when it flogs a garotter? It is not the mere, or even the continuous, infliction of pain which is an offence against moral law, but the unnecessary infliction of pain without an adequate motive to benefit mankind by the act. It is not the mere act, but the motive for that act, which either makes it an offence against morality, or gives to it a justification.

Still, you may grant the motive, but deny the necessity. I need say little as to the motive. Unquestionably the motive is a high one which seeks to extend our knowledge of life and disease, so as, by a few experiments on animals, to ameliorate disease and suffering, not only in the whole human race, but also in all the animals which come in direct relation to man. This is so clear that it requires no argument in its support. The opponents of vivisection, however, deny its utility under all circumstances, because they assert that experiments on animals give no results to be relied on as regards the human body. This is only one of the ordinary appeals to human vanity, which seeks to find a wide abyss between man and other animals. It is altogether contradicted by the discoveries of modern science. Except in regard to his highly-developed brain, man does not differ widely in his bodily functions from other animals. As Aristotle has truly said, "Nature never goes forward by leaps." There is a continuous chain, with slowly diminishing links, from man to the lowest animal. If you place the blood or flesh of a man and the blood or flesh of a sheep

in the most expert chemist's hand, he can detect no difference between them. The same kind of heart, lungs, liver, and spleen, is found in the animals experimented upon as in man; and the same anæsthetics, the same drugs or poisons, and the same parasites, act upon man and such animals in the same way. It is quite certain that the observations made upon animals can be applied by physiology to man, for man physiologically is the king of all animals. But I deny altogether that an unskilled public can form an adequate judgment on these points. The utility and the necessity for such experiments are most important considerations, but they must be determined by the opinion of experts. I do not mean by the few experimentalists in this country, not above forty or fifty in number, but by the whole body of medical men, who devote themselves to the cure and amelioration of disease. They are the qualified judges of the utility and need of making such experiments, and from the results of which they benefit. Outsiders, who have no knowledge of the requirements of surgical and medical science, are not witnesses having a right to be heard in such a case. Now, among 24,000 medical men in this country you will, no doubt, find a few who deny the utility of such experiments. The vast majority of the medical profession are emphatic in their testimony. In August, 1881, there was a great International Congress of medical men in London, and the Congress passed the following resolution:—

"That this Congress records its conviction that experiments on living animals have proved of the utmost service to medicine in the past, and are indispensable to its future progress, that, accordingly, while strongly deprecating the infliction of unnecessary pain, it is of opinion, alike in the interest of man and of animals, that it is not desirable to restrict competent persons in the performance of such experiments."

This Congress was remarkably representative of all countries

both from the Continent of Europe and of America. Lest you should think it tainted by the presence of foreign experimentalists, I may cite the testimony of the British Medical Association, which, on the 10th of August in the same year, passed the following resolution :—

> "That this Association desires to express its deep sense of the importance of vivisection to the advancement of medical science, and the belief that the further prohibition of it would be attended with serious injury to the community, by preventing investigations which are calculated to promote the better knowledge and treatment of disease in animals as well as man."

I cannot conceive that the House would reject such testimony, coming from the great body of medical men, including such names as Jenner, Owen, Paget, Darwin, Carpenter, Sanderson, Huxley, Gull, and a host of others, whose scientific knowledge is only equalled by their broad humanity.

While, however, the House will admit the weight of such testimony, it is entitled to ask what is the nature of the knowledge acquired which has produced this conviction on the minds of the great body of the medical profession.

There are three classes of experiments made upon animals. The first class aims at acquiring knowledge concerning the processes of disease; the second is concerned with the action of drugs or poisons, and the third tests the origin of disease by actually producing it.

The first class seeks for knowledge of vital processes or diseased conditions. Such experiments were made by the ancients, and, since medicine became a science, by physiologists in our own country. The great discovery of the circulation of the blood by Harvey was determined by experiments on a variety of animals, and was ultimately demonstrated before Charles I. and the princesses upon a living deer. In the progress of such experiments by men like Harvey, Hunter, Bell, Brodie, and many others, great

and leading discoveries, such as of the circulation of the blood, the lacteal and lymphatic system of vessels, and the compound function of the spinal nerves, were established. Such experiments, probably, often originated in the love of knowledge only, without immediate reference to its application to the amelioration of human or animal existence.

Nothing is more shortsighted than the utilitarian cry of the ignorant against investigators in science. It is as superficial as the remark of Savarin, when he said, "He who invents a new dish does more for humanity than he who discovers a star." But exactly as navigation is an outcome of astronomy, or as bleaching or dyeing is an outcome of chemistry, or as engineering is an application of mathematics, so is medicine an outcome of the sciences of physiology and pathology. To strangle these sciences, by refusing to them the only modes of research which render their progress possible, would be to relegate the medicine of the future to empiricism and quackery. Indeed, nothing is more certain than that every abstract truth given to the world constantly leads to the most unexpected and most useful applications to humanity. Thus, when Galvani put a copper hook through the spine of frogs, and hung them on the iron rails of his balcony at Bologna, in order to study the muscular contractions which were thus produced, who could have predicted that this experiment was to originate the science of Galvanism, and lead to the discovery of the electric telegraph, to the electric light, to new motors for our machinery, and to the important use of electricity in the cure of disease and relief of human suffering? So it is with other discoveries in physiology, which, even when they appear remote from practical application, constantly lead to the most important benefits. When Pasteur and Lister made experiments on the minute organisms which appear during fermentation and putrefaction, who could have predicted that the experiments of the former philosopher would

have opened up such a wide field of promise in the treatment of diseases which afflict our flocks and herds, or that the observations of Lister would give us that admirable method of antiseptic treatment which now ranks as one of the greatest improvements of modern surgery? And yet Lister had to go abroad to perform a few experiments on animals, as the present Act was too restrictive for him to perform them in this country, though the pain inflicted was no greater than the healing of some slight wound. When you recollect the horrible pain which used to be inflicted after a surgical operation, by burning the bleeding vessels with a red-hot iron, the successive steps in surgery that have attended experiments in the healing of wounds, and which have culminated in the antiseptic treatment of Lister, have surely justified the small amount of brute suffering by giving comparative safety to the most formidable surgical operations in the case of man.

The second class of experiments, with drugs or poisons, are sometimes absolutely necessary, not only in the interests of medical science, but in the cause of justice. The promoters of this Bill would not even allow experiments in the cause of justice. For myself, although formerly a professor of chemistry in the greatest medical school of this country, I am only responsible for the deaths of two rabbits by poison; and I ask the attention of the House to the case as a strong justification for experiments on animals. Still I should have been treated as a criminal under the present Act, had it then existed. Sir James Simpson, who introduced chloroform—that great alleviator of animal suffering—was then alive, and in constant quest of new anæsthetics. He came to my laboratory one day to see if I had any new substances likely to suit his purpose. I showed him a liquid which had just been discovered by one of my assistants, and Sir James Simpson, who was bold to rashness in experimenting on himself, desired immediately

to inhale it in my private room. I refused to give him any of the liquid, unless it was first tried upon rabbits. Two rabbits were accordingly made to inhale it; they quickly passed into anæsthesia, and apparently as quickly recovered, but from an after action of the poison they both died a few hours afterwards. Now, was not this a justifiable experiment on animals? Was not the sacrifice of two rabbits worth saving the life of the most distinguished physician of his time—of one who, by the introduction of chloroform, had done so much to mitigate animal suffering? Would that an experiment of a like kind on a rabbit or a guinea-pig had been used by John Hunter, who probably shortened his own noble life by experimenting on himself with the ignoble poison of syphilis. Let me give one other instance, in which two valuable lives were sacrificed for want of such experiments. A few years ago two young German chemists were assistants in a London laboratory. They were experimenting upon a poison which I will not even name, for its properties are so terrible. It is postponed in its action, and then produces idiotcy or death. An experiment on a mouse or a rabbit would have taught them the danger of this frightful poison; but, in ignorance of its subtle properties, they became its unhappy victims, for one died and the other suffered intellectual death. Yet the promoters of this Bill would not suffer us to make any experiments on the lower animals so as to protect man from such catastrophes. It is by experiments on animals that medicine has not only learned the benefits, but has also been taught how to avoid the dangers of many potent drugs, as chloroform, chloral, and morphia.

The third class of experiments is in the production of disease. At the first blush this would appear to be the infliction of animal suffering without a beneficent motive. But this is the exact reverse of the truth, for no one can know how to prevent disease without knowing how to cause

it. Prevention of disease is a much higher aim of medical science than its amelioration or cure. Now, in this class of experiments, the greatest progress has been made in recent years by the sacrifice of a few of the lower animals. A large class of disease, both in man and animals, is now ascertained to arise from the introduction into the system of self-multiplying and destructive germs of a very low class of living organisms. The promoters of this Bill would not deny this, but would say—"Observe the necessary facts when disease occurs, and draw your deductions from them, without experimenting upon animals." So you may, if you are content with the sacrifice of hecatombs of human beings to obtain knowledge which the sacrifice of a few mice or guinea-pigs would equally give you.

Take an instance in point. A foreign experimentalist—Thiersch—by sacrificing fourteen mice, found that the germs in choleraic discharges, imbibed through water, reproduced cholera with certainty. The same fact, it is true, was suspected in the cholera epidemics of 1848-9, and of 1853-4, when the Southwark and Vauxhall, as well as the Lambeth Water Companies, supplied water tainted with choleraic evacuations to about half a million of their consumers. In the case of Lambeth, during the first of the epidemics, 125 out of every 10,000 of the population died; but in the second epidemic, only 37; for, in the interval, the quality of the water was improved. The Southwark and Vauxhall Company made no such improvement, and the cholera deaths were, 18 to 10,000 in the first, and 130 in the second epidemic. These experiments with water charged with fæcal matter on 500,000 human beings were valuable to medical science, but not in the least more valuable than Thiersch's recent experiments on 56 mice, of which 44 took the disease, 14 of these having died. Had these been made anterior to the cholera epidemics, the great mortality might have been averted.

It is thus that much needless experimentation on man is constantly saved by a few experiments on animals. The recent experiments made for producing disease in animals are full of promise for the future prevention and amelioration of disease in man. This is especially the case in consumption, which is accountable for one-seventh of the total deaths, and for one-third of those persons who die young. Time does not allow me to describe these experiments. I will only mention one fact, that the milk of consumptive cows is found to produce tuberculosis in animals. As the milk of such cows is frequently distributed, it is surely wise to make some experiments on animals, rather than to parody them on some thousand men and women before the danger is either negatived or affirmed.

The House then will perceive that numerous consequences must flow from the establishment of the fact that many diseases of animals arise from the planting in their blood of minute germs of alien life. Take one instance merely. Since the time when in Egypt there was a grievous murrain, "the breaking forth of blains upon man and beast throughout all the land of Egypt," the same disease, *anthrax*, or splenic fever, has desolated the flocks and herds of all countries, from the reindeer in Lapland to the cavalry horses in India. In France this fever kills sheep to the value of 20,000,000 francs annually. Pasteur has shown how the bacillus which produces it may in a milder form mitigate its virulence, by becoming as protective and innocuous as vaccine virus. Large flocks of sheep are now thus protected by it in France. More recently, by a masterly series of experiments, the violent virus of hydrophobia has been mitigated, and that disease has been brought under treatment.

I do not like quotations from the Bible in this House; but I cannot help recollecting that He who is all merciful has said, "How much then is a man better than a sheep."

If we extend such protection to man against the attacks of many maladies which are produced by similar germs, the sacrifice of a few mice or guinea-pigs, which would only suffer a short and slight pain in inoculation, would surely be justifiable in obtaining a lasting boon to humanity. How much more limited is this infliction of suffering than that of our daily intercourse with animals. If the House desire not to interfere with the cruel operations on cattle to fit them for human food or labour, if it does not wish to stop the inoculations which have produced such important consequences in splenic fever and chicken cholera, in protecting cattle and poultry, why should we be asked to prevent the extension of knowledge for the benefit of the human race?

I am much indebted to the House for listening to me so long on a subject which requires so much scientific explanation; but to my medical constituents, who are numbered by thousands, the decision of the House this day will either carry dismay or satisfaction. I must remind you what the Royal Commission told us would be the consequences of passing a Bill of this kind. They said, to prohibit experiments on living animals "would inevitably lead either to a general evasion of the law, or to a universal flight of medical and physiological investigators to foreign schools and laboratories, and that by this means the general treatment of animals would certainly not be altered for the better."

You may retard, but you cannot arrest, the progress of science. Even the burning of the Alexandrian Library did not stop the growth of Literature. By passing this Bill you might produce the result which the Royal Commission so much deplores. This House has already passed an Act to regulate experiments on living animals, and I have shown how successful that Act has been in its operation. You might increase its restrictions; but these are already tightly

drawn, and increased restriction might be followed by evasion. The present Act excludes the unqualified from making such experiments, and entrusts them, with suitable precautions, to the skilled physiologist. Why should you show increased distrust, when there is no evidence of any breach of the existing law? The general presumption of law is, that well-qualified medical men may be trusted for their skill, and for their humanity, even with human life. You allow a medical man to judge whether, in certain cases of childbirth, he may kill the child in order to save the mother; and we are asked to distrust the few and the most specially qualified of that profession to judge whether a mouse, a guinea-pig, or a frog, may be sacrificed for the benefit of the human race. You cannot be surprised that, as a representative of a great medical constituency, I should speak warmly on this subject. That profession has always been marked for its self-sacrifice and devotion to the interests of humanity, and its members naturally resent the imputations of cruelty which are made upon them, because they desire that knowledge all-important to man should be extended in the only way which is possible. I do not at all undervalue the humane feelings and sentiments of many of the promoters of this Bill, though much of the out-of-door agitation in regard to it has been got up in a spirit of unthinking and aggressive ignorance. I assert that physiologists are actuated by a higher humanity than that of the opponents of vivisection. Their aim is to mitigate the sufferings of humanity by studying the processes of life and of disease. The only way in which they can prosecute this aim is to experiment on living beings, not on dead corpses.

The total number of laboratories in the whole world engaged in studying the laws of life, with a view of lessening the immense amount of suffering among all animated beings, are but few in number. In this country, at least, they are conducted and regulated under an Act which has

given statutory effect to the pervading spirit of English physiologists, that the experiments on animals should be made with a minimum amount of suffering.

I cannot believe that this House will give a second reading to the Bill, which would drive English physiologists to foreign countries, or make them work secretly to evade an unjust law, and would thus brand as criminals men whose whole object is to ameliorate the condition of suffering humanity. Limited as is the scope of this Bill, its purpose is to repeal an Act under which the official inspectors assure us that scarcely ten animals in the year suffer sensible pain; but it would take no account whatever of the torture or cruelty perpetrated upon animals out of the most wanton and purposeless malignity.

(MR. R. T. REID: That is a crime already.)

I beg your pardon. It is not a crime already. It is a crime only in the case of domestic animals. I say, it is only experiments made with the noble motive of relieving the ills of suffering humanity with which you propose to interfere. The existing Cruelty to Animals Act, called Martin's Act, is confined to domestic animals only. All other vertebrate animals are excluded from the operation of that Act. If this Bill passes into law, no more protection is given to them, however wantonly, wickedly, and cruelly, any boy or man may treat such animals. It would be a complete defence under this Bill to show that the most cruel experiments were made out of pure malignity, and without any reference to the promotion of physiology, medicine, or science. As soon as the motive is high, noble, and humane, the Bill proposes to brand those who experiment as criminals.

I cannot believe that this House will consent to pass a Bill which has originated in benevolence, but in a benevolence wholly indiscriminate, and which, I believe, will infinitely augment the animal suffering that it ignorantly seeks to alleviate.

THE DISPOSAL OF THE DEAD.

NOTE.—This article appeared in *Good Words*, July, 1885.

THE practice of burial as a mode of disposing of the dead has become universal in all Christian countries, and connects itself unconsciously with our hopes of resurrection. Burial existed as a practice in many heathen as well as Christian countries, and was viewed by the former as a mere means of concealing the dead. The word "burial" is derived from an old Anglo-Saxon word, which means concealment. This was touchingly expressed by Abraham, on the death of Sarah, when he begged for a piece of land "that I may bury the dead out of my sight." The same result was obtained by burning bodies, and the process of cremation prevailed at one time very extensively. Indeed, it was more prevalent than burial, for with the important exceptions of Egypt, India, and China, burning was the common method of disposing of the dead in the old history of the world. From the earliest times burning was practised in the interior regions of Asia, and was followed in the Western World by the Thracians, the Celts, Sarmatians, and other nations. The Jews generally buried their dead, although occasionally they burned them, as when Saul and his sons were burned and their ashes buried under a tree. In Tophet, near Jerusalem, furnaces were kept for destroying the garbage of the city, and also for burning carcases, when made urgent by sanitary reasons (Isaiah xxx. 33). In Rome the burning of bodies was practised from the close of the Republic to the middle of the fourth Christian century. In Greece both burial

and burning were recognised as legitimate funeral rites, though the latter was perhaps more common, as legislative exceptions were made to it in the cases of suicide, persons struck by lightning, and mere infants.

The variations in the methods of disposal were intimately connected with the philosophies and religions of the old world. In the old philosophies matter was supposed to be derived from earth, or air, or fire, or water; and living bodies derived from these were after death supposed to be resolved into them. So the earth philosophers selected burial, while air and fire philosophers preferred burning. Religions had even a more powerful influence in determining the selection of the last solemn rite. Egypt, having a firm belief in immortality, embalmed bodies so that they might remain fit for a future state. Indeed, in that country the most terrible punishment for malefactors was to burn their bodies, so that they should not rise into a more glorious life. In all Christian countries burial has become universal, and the recent movement in favour of cremation comes to us as a startling surprise. In the earlier stages of Christianity there was a simple and primitive belief, which still lurks among the uneducated, that the actual bodies of the dead are to be changed into glorified bodies for immortality. The burning of heretics and infidels produced a horror of this mode of disposing of the dead, and gave to burial a visible sign of faith in the future.

It is useless to inquire whether the universal practice of burial in Christian countries may have given a materiality to our views of resurrection, and may have lessened the spiritual view of immortality. To those who have studied the beautiful words of St. Paul in Cor. xv. the non-identity of the natural with the spiritual body is manifest; but the loving memories which cling to the dead incline us to forget the teachings both of religion and science. No Christian

would deny that the blessed martyrs who were burned at the stake, or devoured by wild beasts in the arena, were as certain of immortality as the believers who are buried. Socrates, who had faith in the future, was asked by his friends, while the poison was numbing his body, whether he would like to be burned or buried, and he replied in very wise words that he cared not which, provided that his friends did not think that they were burning or burying Socrates. Lucan, who wrote in the first century of the Christian era, expressed himself in like terms—"*Tabesne cadavera solvat an rogus haud refert*"—Whether decay or fire destroys corpses matters not. It does not matter to the dead, but it matters exceedingly to the living. We are bound so to dispose of the dead that they shall not injure the living during the process of resolution of the body. Burial, when properly performed, is as innocuous a mode of disposing of the dead as burning. If the coffin be of a perishable nature, if the soil be dry and porous, if the graves be not too crowded, the dead are resolved into air and into ashes as certainly in three years as they are in a furnace in the course of an hour, and in both cases without injury to the living. How rarely are these conditions satisfied in our modes of sepulture! We often find in cemeteries that twenty years are not sufficient to effect the change. The modern Macedonian Greeks have a curious custom. They bury the bodies temporarily, and at the end of three years open the grave. If nothing but bones remain, to these they give permanent and respectful burial, because that proves the goodness of the deceased. If flesh still adheres to the bones, then the dead have become wicked vampires, who are going through the world to do harm to the living. I am afraid that in most of our churchyards the dead are harming the living by destroying the soil, fouling the air, contaminating water springs, and spreading the seeds of disease. It is in the hope of improving our methods of

burial that I write this article. Cremation and burial produce absolutely the same results, varying only in time. The fact that a feeling for cremation has arisen compels those who advocate burial to conduct it with hygienic precautions. Science has reached positive knowledge in regard to the changes of dead matter, and it is right that this should be understood by the public.

It is now known with certainty that dead matter of all organised beings passes into air for the most part, and a small remnant into ashes which remain in the soil. The changed products of the dead—carbonic acid, water, and ammonia—are the food of plants, which, under the action of the sun, mould them into new forms of organic life. Death thus becomes the source of life, and the dissolution of one generation is actually necessary for the support of a succeeding one. The air, the all-abounding air, into which pass all the waste of the living and all the products of the dead, thus becomes the grave of organic death and the cradle of organic life. You may retard the operation of this law of Nature, but you cannot defeat it. The bodies of the Pharaohs have existed, through embalmment, for thousands of years, though they are now gradually being converted into aërial constituents by slow decay in our museums. Every modern burial contributes slowly or speedily to the aërial reservoir of plant food, and takes its part in the great cycle of life and death. There is an old tradition that the body of man becomes entirely changed in seven years; as a fact, all the soft parts disappear and are substituted every six weeks. The materials of our living bodies have mainly come from the air, and to the air must they return. Euripides saw this, though he could not explain it with the lights of modern science.

> "Then that which springs from earth to earth returns,
> And that which draws its being from the sky
> Rises again up to the skyey height."

The main fact that death and life are necessary sequences in the continued existence of the organic kingdom will be most readily understood if we follow out the process in specific cases. It is very obvious in the case of the carnivora. An herbivorous animal lives upon plants which extract their substance from the air. The flesh-eater kills the vegetable-feeder, and the body of the former becomes the tomb of the latter, so in this case death clearly becomes the source of life. Victor Hugo calls the carnivora "the sextons of Nature." The bodies of the consumed herbivora pass into aërial products through the respiration of the carnivora, and by the speedy decay of their excreta, in a quick cycle of life and death, for only a small part remains in the body of the devouring animal. Thus while plants feed animals, they quickly return to the air the aërial food on which plants depend, and here death and life rapidly alternate. Animals which feed on carrion convert the dead bodies into aërial ingredients in about twenty-four hours, just as the crematory produces the same gases in one hour. There is one method of disposing of dead bodies in India that illustrates this change, though it is repulsive to our feelings. The Parsees bury their dead in the "Towers of Silence." In the interior of these towers there are sloping shelves, upon which the naked dead bodies are placed. The mourners withdraw and shut the door; then immediately the expectant vultures swoop down, and in half an hour only the skeleton remains. The bodies of the vultures have become the tombs, and in twenty-four hours the dead bodies have passed through living tombs into air, to fulfil their destined purpose of feeding plants. That is a very speedy mode of burial, though a repulsive one. At all times in history there has been a strong objection to allow the bodies of men to be devoured by beasts or foul birds. Tobit got into all his troubles by burying the king's enemies who were exposed to the beasts of the field. So also did Antigone dare the wrath of the

Theban rulers, when she buried the body of Polynices, her brother, who was exposed to the birds of prey. While we admire this sacred care for burial in the case of a human body, we must not forget that we are daily performing the living entombment of the animals which we consume as food. The carcases of the ox and the sheep are entombed in our bodies, and quickly pass by respiration and excretion into the aerial food of plants. The disposal of the dead is a question of sentiment, subject to a great and inexorable law of Nature, that the dead must ultimately be resolved into the living.

If we follow the process of decay which takes place in the grave, it will be found that living organisms take part in the decay of the buried body, just as they do when beef or mutton is consumed by man. In absolutely pure air flesh does not decay, being, in fact, preserved for an indefinite time. Air is seldom absolutely pure, for in it are an infinite number of floating micro-organisms, either as spores or fully developed. On the tops of mountains these organisms, which are named bacilli, bacteria, or micrococci, are sparsely found ; in the air of the country they are common ; in that of towns they abound ; over sewers or above churchyards they positively swarm. What are they? Are they plants or animals? This is a question that science has not yet decided. Chemists are inclined to consider them animals of a very low type, because animals are chiefly engaged in performing analytical functions, that is, pulling organic matter to pieces ; while plants perform synthetical functions —that is, build up complex organic matter out of simple materials, their main purpose being to mould organisms out of carbonic acid, water, and ammonia. The great function of these micro-organisms which play such an important part in the economy of the world is to convert potential energy into actual energy, or to put it more simply, to convert passive affinities into active affinities. In organised matter

there is for a time the repose of the chemical attractions of the four elements—carbon, hydrogen, nitrogen, and oxygen—which constitute the great bulk of the body. The micro-organisms are engaged in the resolution of the dead body into those active forms of chemical energy—carbonic acid, water, and ammonia. When these innumerable little beings have free play, they are the greatest benefactors to the human race, for they are the most powerful of all scavengers, as they purify air, water, and soil, so as to render them fit for the living. If you oppose their free action, by restricting their access, by shutting out the free circulation of air necessary to their life-functions, they become intensely malignant in their character, the true vampires of the dead: they then fly about planting themselves in the blood of the living, and produce our well-known epidemic diseases—zymotic, or "filth" diseases. In the fluids of patients suffering from such diseases these micro-organisms swarm. Mankind has only recently recognised how much we owe to the micro-organisms. Wine and beer are produced by their agency; by them vinegar is formed, by them we get those vast beds of saltpetre or nitre which is one of the forms into which they convert decaying matter. Our ancestors used to live with rushes on the floors. When the rushes became filthy, new ones were put on the top, and frequently accumulated to considerable thickness. Then the dreaded "petremen" of the king came, and insisted on digging up the clay floor, which had become saturated with saltpetre formed by these busy micrococci, in order to save the inhabitants from pestilence produced by their filthy habits. These little organisms, whether they be plants or animals, are infinite benefactors to the human race or terrible scourges, according as man is obedient or disobedient to the wise laws of the Creator.

By our common practices of burial we do everything to defeat these laws. We enclose dead bodies in close

coffins, in impermeable soils, often saturated with water, so that the air is excluded, and these busy micro-organisms are unable to exercise their beneficial functions. Instead of the simple resolution of the body into the food of plants, which is the end of decay, a vast number of dangerous vapours and fluids are produced as intermediate forms, which may occasion disasters to the living before the little active beings are able to bring them to their simple and destined end of carbonic acid, water, and ammonia. Is it surprising that men who see this with the eye of knowledge should desire to recur to burning as a means of disposing of the dead? The earth is a slow crematory, the furnace is a quick one, but the final results are the same in both cases. The beautiful service of the Church appears to recognise this fact in the alternative words, "Ashes to ashes. and dust to dust." As a chemist, I know that both processes — burial and cremation—are identical, except in point of time. As a legislator, I see no reason why survivors should not be allowed to select one or other method, according to their desires. As a Christian, I wish both to be regulated in their performance and hallowed by those services of religion which are so necessary on such solemn occasions.

The time has come, in my opinion, when those who prefer burial for the dead should be obliged so to conduct it that it will do no harm to the living. I have officially inspected many churchyards, and made reports on their state, which even to re-read makes me shudder. I do not intend to inflict any of these on my readers. The newspapers within the last few weeks have given horrible instances, especially in Ireland. My friend, Mr. Seymour Haden, in his beautiful letters "Earth to Earth," has shown how burial may be conducted with safety to the community. The essence of his system is that the coffin should be of perishable material, such as papier-mache, or wicker-work, so that the air may obtain free access to the body, and

speedily effect that resolution which is not only inevitable, but is necessary in the great cycle of life, that the dead shall yield their material to the living. That is not enough. The earth must be selected on account of its porosity, and to keep it porous it must be adequately drained. Bodies must have space and earth enough for resolution. The holes or ditches into which the bodies of paupers are placed, not separately, but in number, cannot be called graves: they are pits of putridity. If land be too dear to give them decent burial, respectful to the dead and innocuous to the living, a thousand times better it would be that their bodies should be burnt and their ashes buried. Reforms in our modes of burial would vastly increase those tender associations of the past which we desire to preserve in connection with those that are dead. As at present practised, the grave cannot be looked upon with the eye of knowledge except as an evil to the living and a dishonour to the dead. Over a dead body the survivors have no power, for then chemical and physical forces reign supreme. The great law of Nature prevails that death must supply the materials for life. It is this close alternation and mutual dependence of death and life that made old Bishop Hall remark, "Death borders upon our birth, and our cradle stands in the grave." Surely no religious feeling can be offended because I state the well-established truths of science in regard to the wonderful cycle of organic life and death, one of the most exquisite proofs of creative wisdom known to science. Let us take part in the fulfilment of this great law, and not by ignorance or prejudice try to retard it, for we cannot frustrate provisions which were established by the Creator for the welfare of animated beings.

Part II.

INDUSTRIAL WEALTH.

1. THE DEPRESSION OF AGRICULTURE AND FAIR TRADE.
2. THE DISPLACEMENT OF LABOUR BY MODERN INVENTIONS.
3. INDUSTRIAL COMPETITION AND COMMERCIAL FREEDOM.
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Part II.

INDUSTRIAL WEALTH.

THE DEPRESSION OF AGRICULTURE AND FAIR TRADE.

Address delivered at Leeds, 17th Dec., 1887.

To my mind the most significant political event since the close of the session (1887) was the meeting at Oxford of 1,000 delegates of Conservative associations in the last week of November. This gave us the opportunity of knowing the feelings and convictions of the great body of the Tory party. At this meeting little attention was given to the state of Ireland. Its main purpose was to pass the following resolution:—"That the continued depression in trade and agriculture, the increase in the scarcity of employment, and the consequent distress among all classes, render speedy reform in the policy of the United Kingdom as regards foreign imports and the influx of indigent foreigners a matter of vital necessity." When this resolution was put in a substantive form to the congress of 1,000 Tory delegates, only twelve held up their hands against it. The resolution is sweeping in its character, and means that the country must have protection against the imports of foreign commodities and needy foreigners. My object is not to discuss the latter

proposal, although the argument to exclude needy foreigners might be turned against needy Englishmen who leave this country by emigration. It is a separate question, and may mean more or less than the bare words seem to imply. Protection against the import of foreign commodities is thrown down as the gauntlet by the great body of the Tories, and we must take it up.

The basis of this new outburst of fair trade (which, after all, is nothing but protection in a domino) is a real anxiety as to the serious depression of our great agricultural industry. We must all admit and deeply sympathise with this depression. It has been terrible in Ireland, where forty-one per cent. of the people depend upon agriculture; and it is bad enough in Great Britain, where fourteen per cent. are in this position There is no doubt that the diminution of produce and its lower exchangeable value have largely reduced the spendable income of the agricultural classes, and this disaster to them has re-acted upon the manufacturing classes. Let us try to understand how this state of things has arisen. Agricultural depression was accentuated, but was not produced, by the failure in the corn crops all through Europe in 1879, 1880, and 1881, a failure which, in regard to duration and extent, had no parallel in the last four centuries. There was no failure in the United States, so imports from that country greatly increased. The exports of wheat from that country—only 40 millions of bushels in 1871—rose to 190 millions in 1880.

There was a deeper cause at work than the temporary. failure of our crops. The economical applications of science in the vast improvements of the telegraph, the railroads, and the steamships, have changed the whole system of commerce. The effect of these have been to destroy local markets, and to consolidate all into one market—the world. If our landlords and farmers want to know the names of the three persons who have knocked out the bottom of our

old agricultural system, I can tell them. Their names are Wheatstone, Sir Henry Bessemer, and Dr. Joule. The first, by telegraphy, has changed the whole system by which exchanges are made; the second, by his improvements in steel, has altered profoundly the transportation of commodities by sea and by land; and the third, by his discoveries of the mechanical equivalent of heat, has led to great economy of coal in compound engines. By these changes the United States, Canada, India, and Russia, have their corn crops brought to our doors. The effect of these discoveries upon the transport of corn will be realised when I state that a small cube of coal, which would pass through a ring the size of a shilling, when burned in the compound engine of a modern steamboat, would drive a ton of food and its proportion of the ship two miles on its way from a foreign port. This economy of coal has altered the whole situation. Not long since, a steamer of 3,000 tons, going on a long voyage, might require 2,200 tons of coals and carry only a limited cargo of 800 tons. Now a modern steamer will take the same voyage with 800 tons of coal, and carry a freight of 2,200 tons. While coal has thus been economised, human labour has been lessened. In 1870 it required forty-seven hands on board our steamships for every 1,000 tons capacity; now only twenty-eight are necessary. All these changes in the economy of fuel and of labour have led to increased production at a small cost. Four men in the United States working for one year in the growth, milling, and transportation of wheat, can produce flour for a year's consumption of 1,000 other men, allowing one barrel of flour to each adult. I need not elaborate this point further, for you will all see how this has acted upon agriculture. It has made one grain market all over the world. Formerly we looked to the United States alone to supply any deficiency in our crops, but now the transport of grain from Bombay to England, by the Suez Canal, has

been reduced, between 1880 and 1885, from sixteenpence to eightpence a bushel. It is not England alone that suffers in its agriculture from there being a world-market. Italian farmers feel as keenly the competition of rice from Burmah as English farmers do the imports of wheat from India, America, and Russia. It will be no comfort for them to know that farmers of other nations suffer, though it may show the universality of the change if I tell them that American farmers are as low in their minds as English farmers, for the former are looking to a failure in their industry. There are twenty-six millions of people on the other side of the Atlantic dependent on agriculture, who see with alarm that the grain acreage of India is fast approaching that of the United States. The acreage in the latter is now forty millions, and in India it is already thirty millions of acres. And what does the last official report published at Washington say of the feelings of American farmers? "The fear that Indian wheat and cotton and Egyptian cotton are rapidly taking the place of American wheat and cotton has caused producers to feel that the future has no prosperity for them." Note, then, that the farmers in Protectionist America feel the pressure of competition as much as those of Free Trade England. It will gratify the former to know that there are responsible politicians actually proposing, with a view of promoting bimetallism, to render Indian products dearer. This will injure India, but it may benefit America.

I am not surprised that farmers still look with most apprehension to imports of wheat from the United States, because the cost of both land and ocean transport is now so small. Not many years ago the charge for wheat in bulk between New York and Liverpool was sixpence per bushel, while last year its average was twopence-halfpenny. Live and dead meats are also in competition with our home produce, and that trade is still in its infancy. A given

acreage of land which produces six tons of grain will produce only one ton of live stock, so there is much less to carry. Even now the transport of fresh meats from New York to Liverpool, including freight, commission, and insurance, is only one penny per pound weight. Hitherto the English farmers' natural protection against cheap flour and fresh meat from America has been the great extent of haulage, sometimes 1,400 miles to the port. The railways are now doing this haulage with wonderful economy. Let me illustrate it in this way. If I asked a boy to cross the street and post a letter of an ounce weight he would think it ill-requited by a farthing. The American railways will haul 2,000 lbs. of grain for a distance of one mile for less than a farthing. English farmers have had a formidable lesson given to them, that they, like other producers, must adjust themselves to changed conditions produced by the advance of science. Some farmers in other countries have had this lesson in a still ruder way. One of the most important crops in Holland, Belgium, France, and Turkey, used to be the dyeing material called madder. The colouring substance of that dye is now made chiefly from coal-tar, and the agricultural industry for its production has been swept away. So will the growth of indigo in India pass away before long. The grower of sugar-canes is looking with some apprehension at the substance three hundred times sweeter than sugar that is now made from coal-tar. All industries require to re-adjust themselves to the changed conditions of modern production and competition, so that agriculture is no exception to this pressing need.

You will now understand my point, that the agriculture of this country has suffered because of the changes which applied science has introduced. It has made the market of the world one. Still our farmers need not despair, as they have certain advantages. Our climate, notwithstanding its fitfulness, is well adapted to a combined pastoral and

arable culture, and our soil by good farming produces from twenty-six to twenty-nine bushels per acre, while that of the United States produces less than twelve. Canada is more prolific. The labour on English farms is much cheaper than that on American farms, though dearer than it is in India. With these advantages there should be no despair for the future. The great difference in favour of America is in the cheapness of the land, which in the Far West can be got as a freehold for less than our farmers pay for a single rent. There are other differences in our land system which must be altered. The state of the land laws divorces the small tenants and peasantry from the soil, and keeps the latter in a lower condition of agricultural knowledge than in the leading countries of Europe. If all these things be improved it will still take long to adjust British agriculture to the changed and permanent conditions of competition. Hard times are the parents of progress. The intestine war of the United States withdrew one million men from labour on the land, but it stimulated progress in the invention of agricultural machines, and the amount of crops in that country increased every year during the war. I have shown you that depression is not confined to this country. Yet you cannot be surprised that the suffering classes ask you for sympathy, and appeal for due consideration of their difficulties. The landowners and farmers complain that they pay undue burdens, and if that be so, they should be lessened. These are not the cause of the depression, for the local rates upon land are upon an average only one-ninth of the usual rent.

The fair traders, seeing no real help in this direction, turn to their own prescriptions, and desire to restore prosperity by taxing foreign food and taxing foreign manufactures. Their programme is announced in the following words :—

" Duties on foreign manufactures, combined with duties

on all foreign imports of food, but stipulating for free imports of raw material needed for home industry."

Let us see what this means, beginning with the exempted raw materials. Every one would admit that coal is a raw material, and as it is the source of all machine power, not even a fair trader proposes to tax it. Just as coal is the source of power in the steam engine, so is food the source of power in a man. Coal is simply the source of mechanical power, as food is that of animal and human power, both physical and mental. On what principle, then, is food to be taxed and coal to remain free? Careful statistics have been collected in the United States as to the annual expenditure of the families of working men living without alcoholic stimulants, and the result is that £40 is spent for food, £13 for clothing, and £7 for coal and fuel. The amounts, but not the proportions, may be a little different in this country. Now, what is the fair trade proposal? It is to tax the £40 for food and the £13 for clothing, but to leave the £7 for coal free. Of course the tax is to be on foreign imports; though I need not tell you that universal experience in protected countries has shown that a commodity produced at home has its price raised to the extent of the tax put upon the same commodity when imported. If foreign flour be taxed, home flour will rise in price to the amount of the tax. In fact, the only motive of the tax is to enable the English farmer to thrive by an increased price of his produce. What is the tax to be? Mr. Chaplin and Mr. Lowther point out it could not be less than 10s. per quarter if it is to be of any use. This means that wheat at 30s. is to be sold under fair trade at 40s. Thus for every sixpence which you now pay for flour you must then pay eightpence. Recollect the tax cannot stop at wheat, but must extend to all food, including meat. Supposing fair traders were willing to stop at wheat, in order to benefit the English farmer, who has thirty-four per cent. of his

cultivated area in this crop, what are the Scotch and Irish farmers going to say about oats, for the former have seventy-eight per cent. and the Irish eighty-four per cent. under that cereal? You must tax all round if you tax at all. When once the protectionist leech begins to draw blood he becomes like the horse-leech of the Bible, who had two daughters, ever crying, "Give, give!" So protectionists have two daughters—selfishness and avarice—shouting this ugly refrain If you doubt it, look at the case of France and Germany, which have entirely failed to restore agricultural prosperity by duties on food. The French duty on corn was 5s. 3d. and is now 8s. 9d. The German duty of 6s. 6d. did not produce the result expected, and the German Council of Agriculture now asks for 13s. 6d. If you once admit the seed of protection again into the soil of England, you will find it to be a very prolific weed. The cry for protection is as yet the cry of the rank and file of the Tory party, and the leaders are sitting on the fence. At present few of them incline to a tax on food. Lord Salisbury and Mr. Goschen are certainly opposed to that. The others may not be so foolish as to help the farmer in this direct way, but be on your guard that the same result is not proposed and carried by an indirect method. Do not let us forget the indirect proposal to tax manufactures for the benefit of farmers made by Lord Randolph Churchill at Oldham some years ago. It was thorough :—

"Tax foreign iron, foreign machinery, foreign luxuries, foreign calico, foreign wines and beer in fact, all foreign manufactures. The taxing of these would enormously stimulate the home labour market. Tax all these articles boldly, and without hesitation, for the purpose of increasing the revenue, and apply the large sum you would derive from such a source—from fifteen to twenty millions—to the relief of the burdens on land."

That is protection with a vengeance; because, as our imports of manufactures amount only to fifty millions, he must put on duties of 40 per cent. to obtain the revenue which is to relieve the land. No doubt Lord Randolph Churchill has expressed opposite views more recently, but there is no surety that his convictions are permanently changed.

Having dealt with the causes of agricultural depression and the proposed tax on food, let us now turn to the tax on foreign manufactures. I wish to deal fairly with the Oxford platform, and to answer argument by argument, but I cannot find a plank in it that has not been kicked away a thousand times. At Oxford much stress was laid on the old argument that the value of imports into this country is greater than the value of its exports, and that this must produce ultimate ruin because the difference has to be paid out of the capital of the nation. The ruin is slow in coming, although for the last twenty years the value of our exports has, upon an average, been only about 55 per cent. of that of the imports. England would be a bad trading nation if it were otherwise. Suppose, for instance, that a merchant sends coal to India worth £100, and with that brings home rice valued at our ports at £150, the import is greater than the export because it includes the profit on the two transactions. The very essence of trading is to get back more than we give away. Commodities, not bullion, are the materials of exchange. If we paid in bullion for all our imports there might be a case for the fears of the fair traders. What is the fact? Last year the excess of imports over exports amounted to eighty-one millions, but the excess of gold exported over that imported was only £300,000. That small excess probably represents our foreign investments, as England is a great money-lending nation. The annual returns of these investments chiefly come back to this country in the shape of commodities, and add to the excess of the imports over exports.

The fair trader tries to captivate us with the idea that his policy will promote the prosperity of our colonies although it may act hardly on foreign countries. This might be worth discussion if most of the colonies did not tax English manufactures in the full spirit of protection. By a differential treatment in favour of the colonies it is just possible that you might convert them to the views of free trade, but before that conversion is effected three-fourths of the present foreign trade will be endangered or destroyed, and that in its bulk is more important than the colonial trade. The proportion which our colonial trade bears to the foreign trade is about 25 per cent.

Instead of dwelling longer on this point it will be more useful if I employ the remainder of my time in examining the experience of protection in America, from which country I have lately returned I used my opportunities to obtain the best knowledge from both sides. I spent a week with the chairman of the Protection League, another week with the largest landowner in a wheat growing district, and I attended various meetings and dinners of commercial clubs and trade societies. In spite of all attempts to convert me I am a free-trader still. The United States is at once a country of complete internal free trade and of foreign protection. As a free trade country it consists of thirty-eight States and eleven territories containing sixty-four million people. Excluding Alaska, the area of this free trade nation is thirty times as large as that of the United Kingdom, and it has a potentiality of production suited for at least ten times its present population, which you know is rapidly increasing by immigration. All through this vast country unlimited internal free trade exists. No State can put up a Customs barrier against another, so this compact group of United States differs very much from the relation which England holds to her sixty-seven colonies and possessions, for many of them do charge protective duties against English

manufactures. The material interests of the thirty-eight States are far from being identical. The manufacturing interests of the New England States come into sharp rivalry with those of the Southern States, but no protection to either group is allowed on this account. As a nation the United States offer an admirable example of the benefits of free trade. It has risen to this prosperity chiefly by this internal freedom of trade in a growing country, and it will continue to prosper as long as its manufacturers do not glut the internal market — that is, until their production does not exceed the demands of the population with its important annual increment.

On the other hand, the United States is a land of protection against all foreign nations, and let us see how this works. All trades are not protected against the foreigner. Even now there are only two and a half million working men in protected industries as against seventeen and a half million in unprotected. I admit at once that wages are higher in America than here, and this is an absolute necessity, because owing to protection the purchasing power of money is less. It is not true that wages are higher in protected industries; on the contrary, they are generally lower. The highest wages in America are given to blacksmiths, carpenters, masons, tailors, shoemakers, and others who have no protection. In the cotton factories of New England working under protection the cheap labour of the French Canadians and Irish is driving the American operative out of the mills. As a general rule, subject, of course, to exceptions, high wages rule in free industries and low wages in protected industries. The reason for this will be readily understood. Manufacturers have shut themselves out from foreign markets, and are bound to work for the home market. Any surplus of production becomes a glut on the home market, and cannot be relieved by export, for its character is not suited to other countries, even if its high

cost allowed competition. When a glut comes upon the home market, as it frequently does in manufactures of cotton and wool, wages are lowered to meet the internal competition. Over-production does not tell so quickly upon wages in England because we are a great exporting nation, and if there is no market at home we seek it abroad. The United States cannot be so, for her cost of production is raised so high by protection that her exports are of small account in the markets of the world. Compare the two countries—England and the United States—in their intercourse with each other. America has raised against English manufacturers fiscal barriers which might seem to be insurmountable, the duties imposed on our goods being from 30 to 100 per cent. In spite of this she has to buy from this country goods to the value of twenty-seven millions, while she exports to us less than three millions. A comparison of the markets of the world is still more striking. Last year England sent out exports to the value of 212 millions, chiefly manufactures, and America only twenty-three millions. Recollect I am now speaking only of manufactures, not of food. Yet the United States is essentially a great manufacturing nation, with a population honest, industrious, energetic, educated, and, above all, inventive. If she level her hostile tariffs, England will in course of time meet a very dangerous competitor in the markets of the world. As long as there is a rapid increase of population, aided by immigration, American manufacturers are content with their internal free trade, and, fortunately for us, they will not quickly abandon protection. If they do, the United States will possess an enormous advantage over European nations, because, while they prepare for wasteful war by costly armaments, America only prepares for economical industry by new inventions.

Still you may naturally think that the fact of a large immigration in America proves that protection produces

high wages, and that men go over there to seek them. That is an argument quite fairly used by fair traders. What is the fact? The value of immigrants in America is that they become consumers of domestic manufactures and are useful as labourers, not that they become workers in protected industries. I will take the year 1870 by way of illustration, because that year reached the *maximum* of protection as well as the *maximum* of immigration. The number of emigrants who landed in America that year was 387,203. On analysing their occupations it turned out that only 6,960, or less than 2 per cent., went over to make manufactures which either could be or were protected.

I have not time to allude at any length to the absurdities and crudities of the American tariff, though I will give one single illustration in regard to the woollen manufactures of Leeds. The highest quality of such goods is West of England broadcloth. I am not sure of its market price just now, but let us take it at 14s. 6d. per yard. Upon that cloth America charges a specific duty of seventeenpence per pound weight and an *ad valorem* duty of 40 per cent., making together a duty of 50 per cent. on the price of the factory at Leeds. Pass down from the highest to the lowest or cheapest kind of woollen goods, called "cotton-warp reversible cloth"—a sort of imitation of a better kind, which sells at about 1s. 10d. per yard at the factory. Upon that low class of goods the same specific duty is charged as upon fine broadcloth, and 35 per cent. on the value, so that together the duty amounts to 181 per cent. on the price paid at Leeds. That is to say, the rich man in America who buys broadcloth pays an increase of 50 per cent. on its value, while the poor man, who might satisfy himself with the cheaper material, pays 181 per cent. on the price. If duties are justifiable at all, they should be put on the labour cost of production, but they are really put haphazard, without any principle, and just as separate and

selfish interests obtain ascendency in Congress. The fair traders never tire of pointing to America, and wish us to inaugurate a similar system in this country. If they are in possession of a secret principle which will prevent inequalities and absurdities, why do they not make it public? I quite agree with Mr. Bright when he says:—"I should like to see a carefully drawn tariff of the fair traders, protectionists, and monopolists, who are now asking for public support. It would be an amusing exhibition of ignorance, and folly, and confusion."

If you can bear with me a little longer I should like to say a few words about American shipping. Oceans which once separated nations are now the links which bind them together in close union, and the telegraph under the ocean effects a commercial union of the closest character. America has an extended seaboard, and seems intended by nature to be a great maritime nation. And so it was as long as ships were built of wood, and propelled by sails. The Americans had (and, as their yachts prove, still have) a genius for shipbuilding. Formerly their fast clippers filled our ports and gave us lessons in shipbuilding. Both countries—England and America—were running a hard race for mercantile supremacy in those days. There is something in the pride of a people which makes commerce fascinating, for it lays the world under contribution, and brings the treasures of other climes to our doors:—

> "Let India boast her palms; nor envy we
> The weeping amber nor the spicy tree,
> While by our oaks these precious loads are borne,
> And realms commanded which those trees adorn."

Since Pope wrote those lines the oak has been replaced by iron, and this change caused America to lose her position as a shipbuilding nation. The reason of this is not far to seek. Protection has so raised the price of iron and other materials

for shipbuilding, that a steamship costs 30 per cent. more to build in America than it does in England. There is an economy in large ocean steamers as regards the crew. A small steamer of 300 tons requires one sailor for every 20 tons, while a steamer of 1,000 tons needs only one sailor to 41½ tons. The natural tendency, therefore, is to make ocean steamers large, and already they are 4,000 tons and upwards. Suppose a steamship of this size costs £100,000 in England, if built in America its cost would be £130,000. This difference is caused by protection, and it has practically swept the commercial flag of the Stars and Stripes from the ocean. There are numerous passenger and cargo steamers belonging to the United States built of wood, to carry on the coasting trade from which foreign countries are absolutely shut out by navigation laws. Altogether there are only 200 mercantile iron and screw steamers of considerable size under the American flag, used for the coasting and Pacific trade. They have been all built since 1872, chiefly in the Delaware River, and I do not think any of them cross the Atlantic. We build as many steamships in one year as America has taken fifteen years to obtain. Let me quote the manifesto of the League which now cries out for bounties on American shipping:—

"Thus England's marine to-day is triumphant on every sea, and ours successful in none except in our coasting trade, wisely covered by protection."

And so the daughters of protection, like those of the horse-leech, again shout, "Give, give!" in the form of bounties. The League met in Boston while I was there in October last. The bounty asked was an annual subsidy of two millions of pounds, and this meeting was held in 1887 in the same Boston which in 1775 threw the tea into the harbour because the English Parliament had put a small duty upon it! but Boston is tolerant of opinion, for it allowed me to deliver a free trade speech at a dinner of the

Commercial Club, and gave me a warm welcome. The main difficulty in the settlement of the Fisheries question is that it is necessary to keep the fishing vessels of New England in an efficient condition as a nursery for seamen. Protection also has ruined the fishing industry so far as American citizens are concerned. The fishing vessels of New England are manned by British or Canadian sailors to the extent of 75 per cent. of their crews. Although the law requires the captains to be Americans, as a fact, 18 per cent. of them are no longer so.

Protection, when it finds a large rent in any particular industry, tries to mend it out of the same material. The process is always the same—always mending, always destroying. It is as if a man, having a hole in his coat, cuts a piece out of his vest to repair it, and finding that unsightly takes a piece of his trousers to mend the vest. In process of time, by a round of these operations, the garments become rags, and the nakedness of protection is seen through them. The fair traders admit these anomalies in American protection, but point to the prosperity and surplus of the national revenue, and boast that there are no trade depressions like those in our own country. I will show you presently that this surplus is a great evil, and as to American depressions, they occur simultaneously with our own, and of late years they have been more severe. There have been twelve series of marked depressions of trade in this century, and America has felt them all, and since 1830 synchronously with our own. The depression of 1882, which still partially prevails but shows distinct signs of ending, acted severely in America, for the official record says that in 1885 no less than 1,000,000 working people were out of employment. Applied to our own population this would give a proportion of 600,000 unemployed in this country, which would be a ludicrous exaggeration of our troubles in that year.

Now as to the American surplus revenue, which the fair

traders wave as a huge flag in our face. The recent Message of President Cleveland has been expected for years, because the lessening of taxation to diminish the surplus was the main plank of the Democratic platform when he was elected. There is now the wonderful surplus of twenty-two millions sterling, all, except the Excise, got from taxes on foreign goods. Recollect that Americans are doubly taxed, first for the support of their own State, and secondly, for the maintenance of the Union—together £8 10s. per head. The President naturally objects to the Treasury of the United States being a hoarding-place for money needlessly withdrawn from trade and the people's use. To make this clear let me say a few elementary truths about taxation. Taxes are a tribute paid to a State or Government for protecting all of us against violence, rapine, and other forms of crime. Taxation can never be a productive force; on the contrary, taxes form a deduction from the strength of labour and the fertility of the soil. If this be true the more you tax a people the more you decrease the common wealth of the nation. That is the plain meaning of the President's vigorous words. "Heavy taxation has crippled our national energies, suspended the country's development, prevented investments in productive enterprise, threatened financial disturbance, and invited schemes of public plunder." Let us remember the meaning of the word "State." In old times it would have been difficult to define it. A great French King once said, "*L'État c'est moi.*" In history we have known the State, if not to consist of, certainly to be managed, in their own interests, by a barber, a fiddler, or a courtesan. There is no difficulty in defining a democratic Republican or a democratic Constitutional State like the United States or the United Kingdom. The State means all of us, or, at least, selected men to take care of the interests of all of us. When taxes are laid upon the whole people to favour

particular classes, such as farmers or manufacturers, then the State is losing its chief function of acting in the interests of all of us, and is specially favouring some of us at the expense of all of us. That is going back to bad and exploded forms of government, when it favoured class legislation. This is what protection must always do, and has so conspicuously done in America. There privileged classes have laid a claim to be upheld by the labour and self-denial of other people. We allow only one class of the people in this country to make such a claim, and that consists of paupers; and we should be specially jealous to allow any other class to sit on the same plane. Ever since the introduction of free trade, fifty years ago, we have laboured to root out the privileges of class, so that all of us might have equal participation in the protection of social order by the expenditure of taxes. The principle of free trade is that we should use our property and the products of our labour as we like, and exchange them when and where and with whomsoever we will. Protection, on the other hand, hampers exchanges, regulates prices by tariffs, and acts as if commerce meant a war of retaliation on other countries. If protection be universal it raises the prices of all commodities; if partial it forces the State to depart from its only true function of taking care of all of us in order that it may favour the interests of some of us. Its breakdown in the United States shows conclusively that every unnecessary tax becomes a source of positive injury, for taxation at its best is an evil. If we were all good and virtuous over the world it would not be required; but it is a needful evil because a government is necessary to sustain the weak, to protect property, and to preserve the honour of women —in fact, to maintain social order. Protection denies this limited use of government, and, believing in the productive power of taxation, is trying to make something out of nothing. It tries to uphold taxation by taxation, itself by

itself—as sensible an effort as if you tried to lift yourselves by tugging at the straps of your own boots. The development of commerce, like all evolutions, depends on natural laws, which ought to be left to themselves. By intermeddling you would be as foolish as the boy who, in his impatience, manipulates a plant with the hope of getting a bud to blossom before its appointed time. The competition of the world has become so keen, owing to the causes which I have explained, that many industries besides agriculture have been fundamentally changed. Fashions change or new demands arise, and factories must make a complete alteration in their machinery to meet the new conditions. When steel, for instance, substitutes iron, the whole manufacture has to be adjusted to the new application. Manufacturers do not dream of asking the State to bear the cost of adaptation to new conditions of competition. They bear the loss and ultimately benefit by the gain. It is only because the producers of food constitute a large industry that they persuade themselves they have an exceptional claim to aid from taxation. A State that has enjoyed the blessings and the liberty of free trade for forty years will not consent that all of us should be taxed for the benefit of some of us, or, in other words that the labour employed in successful industries should be burdened to support another industry which has not yet adjusted itself to the changed conditions of the world.

DISPLACEMENT OF LABOUR BY MODERN INVENTIONS.

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Periods of depression in manufacturing industries are common in all machine-using countries, generally occurring at the same time and extending over the same periods. During the present century there have been twelve marked periods of depression,* short, sharp, and severe in the early part of the century, because then machinery and hand-labour were in full conflict. From the year 1837 to 1873 the periods of depression were at tolerably regular distances of ten years. Since 1873 the depression has been persistent, with a short cessation for special industries in 1879-1882, after which prices maintained their abnormally low level. As this prolonged depression has been common to all machine-using countries it must have one cause, dominant and universal in its character, sufficient to govern the local differences of countries and nationalities, with all their diverse fiscal arrangements. It matters not whether the countries were devastated by war or remained in the enjoyment of peace; whether they were isolated by barriers of Protection, or conducted their industries under Free Trade; whether they abounded in the raw materials of industry, or had to import them from other lands; under all these varying conditions, the machine-using countries of

* The marked depressions in the United Kingdom have been in 1803, 1810, 1815, 1818, 1826, 1830, 1837, 1847, 1857, 1866, 1873, 1883.

the world have felt the fifteen years of depression in the same way, although with varying degrees of intensity. During this lengthened period the hand-labour countries were not seriously depressed, though in the later years since 1883 they have suffered in sympathy, because the purchasing power of Europe became lessened, and the commodities grown by the hand-labour countries of Asia and Africa were not in demand at the old prices. Thus, comparing the years 1885 and 1886, the prices of exports, as given in the *Economist*, declined in the latter year 6·34 per cent., while prices of imports declined 6·37 per cent. In other words, the prices fell all round, practically the same both as to buying and selling. The machine-using countries have a population of 400 millions, or if we exclude Russia, which is scarcely a machine-using country, of 300 millions; while the hand-labour countries contain one thousand million people. The depression in the former has been general and synchronous, so that this universal result must have a universal cause. In a speech which I delivered at Liverpool some years ago I formulated this cause in the following words—"That the world has not yet accommodated itself to the wonderful changes which science has produced in the modes of production and in the exchanges of commerce." Since that time many writers on political economy have independently arrived at the same conclusion. Among foreign writers may be mentioned Dr. Arthur von Studnitz, of Dresden; Piermez, of Brussels; Jules Duckerts, of Verviers; Emil de Laveleye and Trasenster, of Liège; Annecke and Engel, of Berlin. In the United States, Carroll Wright, the Commissioner of Labour. David Wells, and Atkinson, have written admirable treatises supporting this view as the cause of the long depression. It is important that the reason for this conclusion should be clearly stated, because, if it be true. all partial remedies, such as Protection, Fair Trade, Bimetallism, and the like, can only

have local effects, which may benefit or injure particular countries, but can do little to mitigate the universal depression. All the great countries have had Commissions or Committees of their Legislatures to inquire into the causes of the general depression, but, as the inquiries have been confined to their own countries, none of them have taken a sufficiently broad view of a universal cause. The Committee of Congress in the United States have taken evidence upon 286 causes for the depression, and point to the same number of remedies. Our own very voluminous inquiry in this country produced a majority and minority report. the first being practically that things had better be left to themselves, and the second that Fair Trade is to be our salvation. My object in the present article is to contend that there are only two causes of the universal depression, viz. :—

1. That the improvements in machinery, by new inventions, have produced great changes in the quickness and economy of distribution of commodities, and have profoundly altered the whole system of commerce.

2. That the improvements of machinery used in production have increased the supply of commodities beyond the immediate demands of the world, and have too rapidly displaced the old forms of labour.

At the end of last century and in the early part of the present one there were severe depressions caused by the rapid application of machinery to industrial employments after Watts' improvement in the steam-engine. The sufferings of the hand-labourers were severe, and labour riots, in which mills were burned and machinery destroyed, showed the acute conflict then existing between manual labour and mechanical power. Our late depressions have been altogether of a different kind. Labour has suffered much less than capital, for, on the whole, there has been a general tendency to increase wages. The general increase between

1850 and 1883 is 39·18 per cent. In the United States, a land of protection, the increase is 28·36 per cent. between 1860-1883. Even when they have not increased, the large fall in the prices of the necessaries of life has been equivalent to an increase in wages. But during the whole of the depression there has been a downward competition in prices of commodities, so that the margin of profit to the capitalist is now exceedingly narrow. This fall in prices has been nearly universal, though not equal in all countries. The order of the descent is France, Germany, Great Britain, and the United States, the two last countries being at the bottom of the inclined plane. The fall in the prices of food stuffs has profoundly affected the agricultural industry of this country, though at the same time it has given cheap food to the people. As our largest importations of food are from America, I give in a footnote * the reductions in price. The reductions in the prices of food stuffs are far too great to have any important connection with the slight appreciation of gold or the larger depreciation in silver. Countries with a protective fiscal system feel the latter less than England, because they have few direct dealings with silver-using nations. The volume of trade with hand-labour countries is immense, but their credits are small, and their banking systems are limited. The raw materials which they grow—such as tea, coffee, sugar, rice, hemp, wool, cotton, spices, indigo, and dye-wood—are shut out or hampered by duties in protected countries, so this produce naturally gravitates to England as a land of free ports.

During the continuance of the long depression both wages and the prices of commodities have declined from the high level on which they stood during the few prosperous

* The following are the percentage reductions of prices in the United States between 1881 and 1886:—Mess pork, 48½; lard, 46; hams, 24½; oats, 39¼; Indian corn, 43; butter, 47; tallow, 41, flour, 34⅓; cattle, 18⅓.

years preceding 1873. This is true of all countries, but if we contrast the relative position of England and the United States—that is, of two nations under completely opposite fiscal systems—it is found that wages fell more in the latter than in the former. In the United States, between 1873-78, wages of unskilled labour fell from 37 to 50 per cent., and in the case of skilled artisans to a greater extent. In England wages decreased in various trades. Some of them, as among ironworkers, in 1874, to about 35 per cent. Among miners and shipbuilders there was considerable reduction. In the cotton industry, 1877-79, wages fell 20 per cent., advancing 10 per cent. in the two following years. On the whole of the industries of this country wages are believed to have risen 9·74 per cent. between 1872-1883, and to have fallen in the United States 5·41 per cent. Thus England suffered considerably less than the United States. The demand for labour in the latter country contracted so much that the immigrants, who had numbered 400,000 annually in the six years ending 1873, dwindled to 138,000 in 1878. In 1877, half the coal-miners and ironworkers in the United States being out of work, labour riots became serious. In 1885 depression in the United States was so general that 1,000,000 labourers were out of employment. At such times discontent exists and strikes arise; in 1886 there were 350 strikes, involving 450,000 workmen. If such events happen in America, with its protectionist policy, there is little ground for the contention of Fair Traders that Free Trade is the cause of depression in England.

The bi-metallists bring forward their own pet theory of the appreciation of gold and the depreciation of silver, and deem that to be a sufficient explanation of depression. There might be something in this theory if the great transactions of commerce were paid for in bullion. The latter merely settles the balance of exchange, for exchanges are conducted by an interchange of commodities. If the

depreciation of silver had been the cause of the depression in England, which certainly has the largest traffic with silver-using countries, it ought to have been specially severe in 1873-4; for in these years Germany adopted a gold standard, contracting by extensive sales her silver coinage, while France at the same time ceased to coin silver money. By 1875 English industry ought to have been crushed by these changes, but the truth is that then and ever since both gold and silver have been in excess of the demand. Before dealing with what I believe to be the true causes of the depression, it is desirable to consider the general features which have given a common character to the depressions in all parts of Europe. The common features have been the same in all countries—first, that though prices of commodities have been largely reduced, the volume of productions and the business of commerce have not been lessened in anything like the same proportion; second, that when wages have fallen, they have not declined at all in proportion to the fall in prices; and third, that the margin of profit to the capitalist has been very small. Capital, then, during this long-continued depression has suffered more than labour. For some time past, capital, when applied to staple commodities, has been glad to be content with about 10 per cent. of the cost of conversion of raw material into a useful product, while labour has been getting 90 per cent. Of the 10 per cent. which goes to the capitalist only from 5 to 6 can be put to profit, the rest going to the wear and tear of plant and machinery. There is at present a want of harmony between capital and labour which tends to continue the depression. Sometimes working men, not content with the shorter hours of labour in this country, put arbitrary limits to output and to the mode in which the workers shall be employed. Such restrictions to production, lessening the very narrow margin of profit that prevails, have stopped some works and threaten to drive others from this country to foreign parts. A better

education of masters and men, which I contend for later, will show that the interests of capital and labour are not antagonistic, but identical.

Having dealt with these preliminary subjects, I now turn to the discussion of the two immediate causes which have led to the universal depression in all machine-using countries for fifteen years. The first of these I have stated to be the changes produced by science in the economy of distribution, and the consequent and profound alterations which have followed in the commerce of the world. In 1869 the Suez Canal was opened, the result being that the old route round the Cape of Good Hope was in a few years abandoned for the shorter and more economical route to the East. On the old route, sailing ships were chiefly used, and they occupied from six to eight months in the round passage, while now the time is shortened to thirty days. By the substitution of iron steamers carrying the commerce of the Western hemisphere through the Suez Canal, a tonnage estimated at two millions was practically destroyed, and vast arrangements in commercial industry were displaced. In the old system of long voyages, large storehouses of goods had to be provided for the shipping interest, not only in foreign ports, but also in England, which became the centre of warehousing, banking, and exchange. All this was altered by the mighty power of electricity. The electric telegraph had indeed been invented in 1837, but it required many new discoveries in science to adapt electricity to the growing wants of the world. All these have been made in recent times. The three discoverers who have revolutionised commerce—Oersted, of Copenhagen, Faraday and Wheatstone, of London—lived in my own day, and indeed were my personal friends. The applications of their discoveries to the various purposes of electricity—the telegraph, telephone, and electric lighting—have created new labour, but have at the same time displaced a great amount of other

labour. In the United Kingdom upwards of 42,000 persons are engaged in work depending upon electricity, while probably throughout the world more than 300,000 persons win their subsistence by the recent applications of this science. The amount of labour which it has displaced cannot be calculated. The whole method of effecting exchanges has been altered, because communication with other countries is now immediate; the consumer and the producer in opposite parts of the globe making their bargains in a single hour, without the intervention of mercantile agencies or the large warehouse system which former methods of commerce required. The Suez Canal and improved telegraphy made great demands for quick and economical distribution of material. Numerous steamers were built between 1870-3 for this purpose, but so rapid were the improvements that they were nearly all displaced two years afterwards (1875-6) and sold at half their cost. Iron has been largely substituted by steel, both on land and at sea, Bessemer's invention having destroyed wealth; but like the phœnix, new wealth has arisen from its ashes. A ship which in 1883 cost £24,000 can now be built for £14,000. The economy of fuel has also been very great. Shortly before the opening of the Suez Canal, the best steamers crossing the Atlantic expended 200 tons of coal to carry an amount of cargo which can now be driven across for 35 tons. The discovery of Dr. Joule as to the mechanical equivalent of heat stimulated builders, like Elder and others, to apply the compound engine to steamers. This has produced an enormous economy of fuel. In 1850 the fine steamer (the *Persia*) carried over cargo at an expenditure of 14,500 lbs. of coal to a ton; now a modern steamer does the same work by burning three or four hundred pounds. The effect of this economy on haulage by land and transit by sea is immense. In an experiment lately made on the London and North-Western Railway, a compound locomotive dragged a ton of

goods for one mile by the combustion of two ounces of coal. In ocean navigation there is a much larger economy. A cube of coal which passes through a ring the size of a shilling will drive one ton of cargo for two miles in our most improved steamers. The cost of transit of a ton of wheat from Calcutta to England was 71*s.* 3*d.* in 1881 and 27*s.* in 1885. The haulage of a thousand miles, from Chicago to New York, brings a whole year's supply of food for a man at a cost of a single day's wage. A ton is hauled for less than a farthing per mile.* The transport of food has thus told heavily upon the agriculture of all countries, because it has made one market—the world—and has largely destroyed the advantages of national and local markets. I have dealt with the effects of this lowering of prices upon the condition of agriculture in a speech recently published, so I now limit my remarks to manufacturing industry. The lowering of prices, consequent upon the more ready and economical distribution of commodities both by land and sea, has necessarily had an important effect upon manufacturing production as well as upon commerce. The old factors which ruled production were the value of the raw material and the representative value in money of the labour, skilled and unskilled, used and directed by capital to convert the crude material into a finished product. These factors still rule production, but their relative values have rapidly changed in recent times. The raw material can be distributed everywhere at low charges. England has lost its great advantages in the possession of coal and iron—the

* The fall in the prices of ocean transit from New York to Liverpool has been as follows —

	1880.		1886.
Grain, per bushel ...	$9\frac{1}{2}$*d.*	...	1*d.*
Flour, per ton ...	25*s.*	...	7*s.* 6*d.*
Cheese ...	50*s.*	...	15*s.*
Cotton, per pound ...	$\frac{5}{8}$*d.*	...	$\frac{3}{32}$*d.*
Bacon and lard, per ton ...	45*s.*	...	7*s.* 6*d.*

first the source of power, the second the material for strength. The value of raw material in industry is now the lowest factor of production, while the value of intellect in converting it into a utility, in the cheapest and best way, is the highest and dominating factor in manufactures.

I now pass to the consideration of the second cause of depression, as that has much more influence on manufactures than the changes in distribution. This cause is, that modern inventions have produced commodities faster than the world could absorb them at remunerative prices, and in doing so have displaced old forms of labour with too great rapidity for their absorption by replacement. This may be best illustrated by a few special examples. As chemistry is the only science which I profess, I begin with some examples of chemical industries. One of the most staple and apparently permanent dye stuffs, used in dyeing and calico printing, was the root called madder. It was grown as extensive crops in various countries of the world—Turkey, Holland, Belgium, France and Italy—and gave employment to a large number of cultivators. Commerce was startled one day to learn that chemists had made the colouring principle of madder, called "Alizarin," out of coal-tar, and in a short time a great change took place in agriculture, commerce, and dyeing. Madder is still used for some purposes, as in the dyeing of Turkey red, but its importation has decreased from twenty-eight and three-quarter million pounds' weight, in 1872, to about two millions in 1887. The value of the latter in money was only £24,000, while that of the import of "Alizarin" made from coal-tar already exceeds ten times that amount, although it is also manufactured in this country. It occasionally happens that a new invention produces large industrial results without much displacement of labour. We see an instance of this in lucifer-matches, an invention altogether new since 1836, before which time lights could only be got by the

tinder-box. The mere saving of time to the population of this country, by the modern matches, amounts to twenty-six millions sterling annually, while the only displacement of labour was to the makers of tinder-boxes.

Among the recent chemical industries which have most affected the comforts of the poorer classes is the invention of artificial petroleum and its derivatives. Natural petroleum has been known from very early periods of history, though it has not been used extensively till recent years. Its revival occurred in the following way. In the year 1847, Mr. James Young, under circumstances which will be found detailed in the article on petroleum, manufactured it from a native spring in Derbyshire. This he did successfully, but after a time found that he could make it more cheaply by distilling it from bituminous schist. This industry was so successful that it led to the industrial application of the natural oil in America and the Caspian Sea. The industries connected with sperm and vegetable oils were seriously affected, and labour was largely displaced. Another substance got out of petroleum is the solid waxy substance called paraffin, which has now, in the form of candles, given to industry an illuminating agent of great value. Paraffin candles gave a heavy blow to the old industries of making candles from tallow, palm oil, sperm and wax, and displaced labour to a great extent.

Let me pass from these chemical industries to a staple manufacture like cotton, and observe the effect of inventions on production. A farmer growing cotton produces about 400 lbs. per acre, or as much as will produce one bale. Before Whitney invented his cotton gin, the seed had to be separated from the fibre by manual labour, but the work was so tedious that it took one man about ninety days to prepare the produce of an acre. The first form of the gin reduced the time to six days. In recent years this gin has been greatly improved, so that one man can now pick 4,000 lbs. daily

instead of the old amount of 4½ lbs.; in other words, one man with a machine displaced the labour of 999 workers by hand. The cotton thus picked and cleaned is spun into threads by rotatory spindles. They used to be worked by manual labour, one man to each spindle, but now one man and two children will work machines carrying two to three thousand spindles. In 1874, at the beginning of the depression, each spindle made 4,000 revolutions: now it is possible to get 10,000 revolutions. The yarn is then woven into cloth. With the old hand-loom a man could make from 42 to 48 yards daily. At present a skilled workman can tend six power-looms and weave 1,500 yards. All these changes tend to over-production, especially when the margin of profit is low. I believe at recent prices this is only about one penny for six yards of shirting, so a vast number of yards are required to make a substantial profit to a mill. The demand of a working man for cotton fabrics is, upon an average, 40 yards yearly. This demand is determined by his habit of wearing one shirt for a week, and it is difficult to induce him, in order to augment the demand, to wear one daily; or, if he did, to persuade his wife to wash seven shirts weekly. Cheapness of a commodity tends to increase demand, but it does not all at once alter the habits of classes. Supply must be adjusted to the ordinary comforts of the consumers. There is always a growing increment of demand, for, even in the United Kingdom, not far from 1,000 souls, provided with bodies which must be fed and clothed, are daily added to the population. The increase of the whole world during the fifteen years of depression has been about 16 per cent. in population, while the increase in the production of cotton has been 86 per cent. It is not surprising that a surplus like this thrown upon the markets of the world reduces prices.

Manufacturers too often forget that it is not the reasonable price of a commodity, but the surplus of it above the

demand, which regulates the quotations of the market. About half of our exports of cotton go to countries using silver coinage. When new markets are opened in half-civilised countries, the demands depend not only upon the existing standard of comforts, but also upon those which are created by contact with higher civilisation. This is a hope and a policy which Germany is now pursuing with great ardour. Carlyle remarks that the bare problem of supply and demand is very simple. "Here," he says, "are the millions of bare backs, and there are the millions of spun shirts. How are they to be brought together?" The organisation of commerce has to solve the problem, and in its solution nations will take rank in the international competition according to their relative intelligence.

I must be content with only one or two other illustrations of the manner in which inventions give an abnormal increase to production, and displace old forms of labour. It is not in prosperous but in hard times that they chiefly arise. In 1870–72, when trade was active, there were comparatively few inventions. Take the time before the American war in 1861: the patents for new agricultural machines, on the average of several years, numbered 350; while, during the war in 1863, when at least half a million men had been withdrawn from the labour of the field, the patents were 502, and the result was that agricultural production was not lessened at any time of the long campaign. Machinery, on the other side of the Atlantic, is more extensively applied to large farms than here. The reduction of manual labour has become so great, and the methods of distribution are so improved, that, according to Atkinson, the labour of four men will grow, mill, bake, and distribute as loaves one thousand barrels of flour, which suffices to feed one thousand men. Even with less organised machinery we have seen in our times much displacement of agricultural labour in this country, and the result still prejudices the position of Ireland. Irish reapers

cut the harvest crops in England, and took back English money to pay rents in Ireland. With the old sickle a man could reap one quarter of an acre daily; but the machine-reaper came in, and one man with two horses reaps from fifteen to twenty acres. The Irishman was a good workman to thresh out corn by the flail, and managed fifteen to twenty bushels daily; but now one man, tending a machine, can thresh out hundreds of bushels.

In the railways a vast amount of the labour of men and horses has been displaced, but is replaced in other forms by the necessity of feeding the railways with material. If the locomotives on English railways were annihilated, it would require the labour of seventy-five millions of men, or of twelve millions of horses, to carry on the traffic, in an inferior way and at a much larger cost; for the cost of carting a ton weight by a man with a cart and horse, is one shilling per mile, while the railway carries it for a penny or under.

I finish my illustrations by referring to the iron industry. It is of such antiquity that the best and most economical means of production might be supposed to exist. In the year 1846 the British Association for the Advancement of Science requested Professor Bunsen, of Heidelberg, and myself to report upon the chemistry of blast-furnaces, and we showed that at that time no less than 81½ per cent. of fuel was absolutely lost in the form of gases which escaped and were burned at the top of the furnace. In addition to this waste of fuel was the total loss of the ammonia produced by the coal—a substance most valuable to agriculture as a manure. The economy of the ammonia has scarcely begun to be realised at the present day, although our recommendations for the saving of fuel have long since been carried out with much economy to the price of production. There has been a rapid growth of the manufacture of iron over the world, and naturally the increase has been greatest among

nations which were farthest behind. From 1870 to 1884 the make of pig-iron rose 131 per cent. in Great Britain, and 237 per cent. in the rest of the world. In recent times, steel has largely substituted iron for many purposes. Formerly pig-iron was transformed into bar-iron in puddling furnaces, and the latter was converted into steel by a process known as cementation, which consisted in giving to the iron more carbon. Now, by the Bessemer process, steel is made direct from pig-iron, already to the extent of three million tons annually, while four and a half millions of capital invested in puddling furnaces have been destroyed, and the labour of 39,000 workmen has been displaced. To counterbalance these evils the price of steel, which was £12 1s. 1d. per ton in 1874, was less than £4 in 1887.

The illustrations already given must suffice to show how largely modern inventions have increased production and displaced labour. Ultimately, educated working-men benefit by the changes, because increased production absorbs skilled labour and pays high wages for it. Ignorant workers—the hewers of wood and the drawers of water—have a bad time, as they find that the demand for unintelligent labour is constantly decreasing. In old lessons of political economy, production upon a given raw material was represented by a very simple equation—P = L + C. The product equals labour *plus* capital. The equation never was right, because capital is really accumulated potential labour reserved as a subsistence fund for the labourers who are employed to convert the potential into actual energy. Capital or accumulated labour is exactly like a storage battery in which electricity is accumulated. This battery regulates the work which the electricity has to perform, and steadies the electric lights. Labour is now of two kinds; labour in quantity and labour in quality—the first lessening in value every year as a factor of production, while the second is always rising in value. The product is,

therefore, actually the result of three kinds of labour—capital, or accumulated labour, labour of quality and labour of quantity. Even now the terms of the two last forms of labour could only be expressed by multiplying (not adding) the labour of quantity by the labour of quality. Reducing this to a simpler expression, the present state of manufactures depends mainly upon the intellectual condition of the producers. The competition of the world has become a competition of intellect. In the future of the world the greatest industrial nation will be the best educated nation; it may not be so to-day, but it certainly will be so to-morrow. I have already shown how the cheapness and facility of the distribution of commodities have destroyed national markets and local advantages, making all the world into a single market. Formerly it sufficed that a merchant or a trader should be a good citizen of his own country; now he must become a citizen and trader of the world. Our merchants and manufacturers have been slow to see this, and they are allowing other better-educated countries to forge ahead. Every German clerk or trader knows two languages besides his own, and is taught scientifically and practically the wants of commerce. The German Government has established a bank of commerce which, with the efficient co-operation of the consuls living in Eastern and African countries, has had a great effect in extending their colonial markets. A country with a protectionist policy is apt to have an over-production of commodities beyond the wants of the home market, so there is a natural desire to use this surplus in foreign markets at the very narrowest margin of profits. These have certainly been supplied with German goods for the last few years, though the prospect of continued success is doubtful, as they are always handicapped by increased cost of production; still, so far as limited statistics are to be relied on, the policy seems at present to be successful. Taking the period of depression from 1872

to 1886, the increase of German commerce has been 67 per cent., while the maritime tonnage has expanded by 120 per cent., and the bank discounts, indicating activity in industries, have augmented by 240 per cent. How far sacrifices in the prices of commodities have led to these results in making new markets we do not yet know, but the increase is out of all proportion to the growth of the German population, which has only been 11½ per cent.* Berlin, like other towns of Germany, is taking active measures to promote technical education. A central technical institution, costing no less than £400,000, has been erected in Berlin. Might we not hope that the new Imperial Institute in London, though it is on a smaller scale, will undertake like work for London? It may be profitable if we inquire how far the education in Germany or in Switzerland tells upon one particular kind of industry, so I take the silk trade as an example. In the evidence given before the Royal Commission on the Depression of Trade it was stated that the silk industries of Coventry, Macclesfield, and Spitalfields had decreased to about one-fourth their old dimensions. Spitalfields sank much lower, for its former 24,000 looms are now dwindled to 1,200. While Coventry was losing its trade in silk ribbons, Basle, in Switzerland, was making a like industry prosperous by establishing excellent schools for dyeing and design, and that town imports to this country what Coventry lost to it. The town of Crefeld, in Germany, is a still more striking illustration, because by the attention to education suited to its industries, it has, within a few years, doubled its population and quadrupled its trade. This small town, which has now grown to 83,000 inhabitants, has spent £215,000 on its lower schools, and £42,500 on a special weaving school. Who has paid for

* A report on this subject, by Mr. Giffen, has been issued, and shows that English trade has as yet not materially suffered by German competition.

this large educational expenditure? Quite possibly the consumers of silk in England, who get from Crefeld what Macclesfield and Spitalfields fail to produce with equal excellence. The melancholy result is this—that the exports of English silks amount to only £2,670,000, while the imports to this country of foreign silks reach eleven millions. It is useless for our towns to battle by empiricism or by fiscal laws with foreign nations which have equipped their artisans to fight with trained intelligence in the competition. Technical Education is simply the *rationale* of empiricism. It is a melancholy spectacle to see a town like Norwich, once famous for its shawls, actually contending with the Charity Commissioners because they wish to utilise its fine endowments by creating a system of technical education, while the civic authorities struggle for almshouses. Figs cannot grow on thorns, nor can ignorance among our workmen expect to compete with trained intelligence in our industrial competition with other nations.

England is far behind in the technical training of our artisans, but there is hope that we have awakened to our shortcomings. When I first began to call attention to our dangerous ignorance in 1852, there were no higher colleges, except Universities, in any town of the United Kingdom, except Owens College in Manchester, and Anderson's College in Glasgow. Now there is not a large town in Great Britain without such colleges. These are being adapted to the education of the upper classes, and a great step is gained; but continuation schools for the working-classes, and technical schools adapted to their wants, are rising far too slowly. In London the progress is more rapid, and perhaps in a few years we shall be able to boast that we have gone beyond Paris in Polytechnics for the working classes, though we shall still be far behind Berlin and other manufacturing towns of Germany and Switzerland in relation to the population. Still I have faith that the

movement is in progress, for stern necessity will rouse the manufacturers of England to train the intelligence of the producers. Working men are alive to the defects in their education, and their voices will soon be heard in the Parliament of this country. The wages of our artisans are higher than those in Continental countries, and so are their productive powers. I am informed by Sir Lowthian Bell, the highest authority in the iron trade, that where ten men are employed in a German blast furnace, five would suffice in England for the same quantity of iron.

It would require a man much wiser than myself to predict the future of our industries with certainty. One thing is sure, that they cannot recover from depression by putting on their back the old man of the sea in the shape of the fiscal proposal of the Fair Trade party. England depends upon her export trade for her future prosperity, and as exchanges are made in commodities, not in bullion, the restriction of imports by taxation contracts exports to the same amount. Indeed, such a policy must lead to the tariff war which now prevails among most of the Continental States. No fact in political economy is more clear than that taxation on foreign commodities must ultimately be paid by the consumers, not by the producers. All taxation is a deduction from the fruits of labour and from the fertility of the soil of the country imposing it. No political economist has ever been able to show how prices to consumers can be lowered by increasing the cost of production. In countries with a Protection policy there is as much depression, though one of greater intensity than in the countries with Free Trade. In the former there are constant attempts to cure the depression by adding restriction after restriction, in the hope of remedying the evil. It is the same operation as when a person dissatisfied with the working of a machine adds a new cog, then a spring, then a lever, forgetting that with every new addition he is increasing friction and lessening power.

The great industrial machine of this country is good enough in itself, but it needs proper oiling to make the parts work smoothly ; and I have tried to show that the technical education of working men is the lubricant which we so much require. I do not believe that it will again work so as to produce the large margin of profits which we enjoyed in the past. Still there is encouragement that we may carry on a good and steady trade. The cheapening and extension of distribution have probably reached their limits, and little more is to be expected in this direction. New inventions will continue to be made, but not with the same marvellous celerity that we have seen in the last fifteen years. If the United States alters its Protection policy, and becomes a Free Trade nation, it will be our great competitor in the world, though the time is not close at hand. Her large surplus revenue, amounting to twenty-two millions, has invited schemes of public plunder, and her pension list of old soldiers, and compensations to States for aid in the war, amount to a charge equal to a large standing army. When these lapse by time, the United States, with a standing army of only twenty-five thousand men, will become a nation which has only to prepare herself for the progress of industry by new inventions without the cares and costs for the preparation of war. At the present moment the United States has 250,000 inventions protected by the patent law. This activity of invention shows ability and intelligence among her people, who are always ready to turn to account the forces of Nature for the benefit of man. This country in her working men is rich in producers, and if their intelligence were trained in connection with their work, we need not fear the industrial competition of any European nation. All great foreign nations, except the United States, are terribly handicapped in the industrial race by excessive armaments. England is also weighted, but not to an equal extent. The strength of nations consists in peace, but the weakness of

nations is in actual war, or excessive preparedness for it. France, Germany, Holland, Italy, Belgium, and Great Britain have 2,200,000 men withdrawn from being productive citizens, in order to be protective militants, at a cost for each man of £45. If we take all the civilised nations, adding the Reserves to the permanent forces, fourteen and a quarter millions of the strongest men are or may be withdrawn from production. This is one man for twenty-four of the population, or, if we exclude the Reserves, one out of eighty-one. That is the reason why I point to the United States as the great industrial nation of the future, for her armed forces represent only one man in 1,610 of the population. Luckily, her Protection policy is an incubus upon her industry, and gives us breathing time to prepare for the coming struggle.

INDUSTRIAL COMPETITION AND COMMERCIAL FREEDOM.

Address delivered to the National Liberal Club, 1888.

If the depression of trade which has existed in this country since 1874, with only a flicker of revival in special industries from 1879 to 1882, be in any way due to England's Free Trade policy, as, indeed, many persons believe it is, then you cannot be surprised that the working classes, and more especially the unemployed, should have lost faith in the principle which they adopted with enthusiasm in 1846. The depression is universal in all machine-using countries. It did not even originate in England, though in course of time it reached this great industrial country, and has remained with us ever since, as it has done with every other machine-using nation. In former periods of history, depressions in agriculture and manufactures sometimes lasted fifty years without a break, but they differed from the present depression by chiefly affecting labour rather than capital, while now labour has suffered comparatively little, though capital has been struck with severity. Listen to the plaints in former times. Richard Hakluyt, in 1584, writes:—"Yea, there be many thousandes of idle persons within the realme having no way to be set at worke . . . . whereby all the prisons of the land are daily pestered and stuffed full of them, where either they pitifully pyne away, or els at length are miserably hanged, even XXI. at a clappe out of some one jayle." And Sir William Petty, a century later (1691),

The traffic on Indian railways increased marvellously in consequence of this quick outlet, for in ten years, from 1876 to 1886, the volume of traffic trebled, while the average traffic per mile doubled. The substitution of a double voyage of sixty days for one of seven or eight months altered the whole system of commerce, rendering useless the huge warehouses for the storage of goods, and costly foreign agents to obtain supplies. The producer and the consumer, at the two ends of an electric wire, could make their arrangements within an hour. This speedy interchange of views demanded a quicker and more economical means of transit by sea and land; and scientific invention has so improved these that the whole system of markets has been altered. To a great extent national markets have been destroyed, because the world has become the one market for all nations. The increased economy of transit has necessarily lowered prices. Every ton of coal now carries thirty-two times more cargo than it did a few years since. In the best compound locomotives two ounces of coal will move a ton of cargo one mile; and half that quantity will move, in our best steamers, a ton of cargo and its proportion of the ship for two miles. After all, this is only about two-tenths of the potential power which exists in the coal. Take an instance of the effect of this on commerce. A sack of flour can be moved from Minneapolis, in the United States, down to the seaboard, 1,400 miles away, to be sent by steamer to Liverpool, at a total cost for transport of less than ninepence upon the bushel of wheat. The British working man, when he buys a four-pound quartern loaf made of American flour, may reflect with astonishment that it has been brought four or five thousand miles at a cost for transit of one halfpenny. It is not in economy of fuel alone, but also in the economy of labour that modern invention has produced this astonishing result. When the depression began in 1873, the number of hands required for 1,000 tons of shipping in this country

was forty-seven; it is now reduced to twenty-seven. In other words, by labour-saving contrivances at sea and in the port, the same quantity of work can be done with 70 per cent. less manual labour. This explains the fact that while our mercantile marine, between 1870 and 1880, increased its foreign entrances and clearances by 22,000,000 tons, it decreased the men employed by 3000.

The general result of these changes in distribution has been that all countries of the world have been brought into a common market to compete for the margins of profit.

The agriculture of this country was the first great industry to suffer by the changed conditions. It is still one of the few industries of a domestic character which remain in this country. The farmers rather glory in their independence and want of combination. At the same time they have to meet, in their isolation, the competition of land cultivators in other countries, who carry on their industries in enlarged combinations, and with the use of machinery of the newest character, not only for the growth, but also for the harvesting, handling, milling, and transport of the grain and other products of the farm. Without this combination and mechanical advantage, the United States could not now grow 35 per cent. more food stuffs than they did in 1870, allowing for their large increase of population. The harvesting of this grain would require 160,000 labourers in order to cut and bind the wheat, had not this labour been substituted by self-binding reaping machines. The old mills with grindstones could not have converted it into flour; but by steel rollers and other improvements, more than three times the quantity of flour can be got with the labour of fewer men. The American millers now come into direct contact with their customers, because, instead of sending over 200 lbs. of flour in barrels or sacks, they pack it up in neat bags of 2½ lbs. or 5 lbs., to suit small purchasers. By this means they get

a larger price; for while the 359 lbs. of flour got from a quarter of wheat sells at 56s., the wheat itself, from 1882 to 1886, only produced 33s. 9d. Our farmers know these facts, but they are conservative in their ideas, and prefer to see the mills shut up rather than abandon their old modes of work. It is not with the United States alone that our farmers have now to compete, for new markets have arisen in Canada, South America, India, Australia, New Zealand, Egypt, and Russia. All kinds of food are subjected to the same competition. Fresh meat, in various stages of preparation, is imported from the United States, the Argentine Republic, New Zealand, and Australia. This importation is rendered profitable, because the live stock is dealt with by large combinations of producers. The live animals are killed by thousands, their carcases properly cooled, every part of the offal converted into industrial commodities, while the fresh meat is transported in refrigerating cars to the coast, and then put into cooling chambers on board the steamers.

Mr. Tallerman has lately shown, in a useful lecture, that it would be easy to apply this system in the home markets. Oxen sent alive by railway and driven to the butcher's are stated to lose twenty-four pounds in weight by three days' travel. County slaughter houses, conducted on a manufacturing system, provided with proper cooling chambers, and with appliances for the utilisation of the offal, might promote a dead meat market, which would lessen the need for foreign importation. Perhaps new county government may lead to these appliances. Unless the competition is met in this way, it is likely to increase, because the weight of meat products is less than that of grain, the same area of land producing in live stock only a sixth the weight of cereal food. Even at present the value of imported dead meat of various kinds amounts to above thirteen and a quarter millions sterling. Our farmers have recently begun to attempt

combination in a small way with dairy produce. It is full time that they should do so, when butter and butter substitutes, which are really true butters made from the ox, instead of from the cow, are imported to the extent of eleven to twelve millions. Foreign cheese is imported to the extent of four to five millions sterling; poultry and eggs of the value of between three and four millions. Condensed milk, obtained by simple evaporation, comes to us from the Continent to the extent of twenty-five millions of cans. It is neither the climate, nor the soil, which stands in the way of our successful competition in food products. The soil gives nearly double the produce of grain that it does, on the average, in the United States, and the climate, though variable, is admirably adapted for a combined system of pastoral and agricultural industry. The age of domestic manufactures is past, and English agriculture has now come under the common law of production. The conditions under which its products can be manufactured by combination and machinery have been established, and are in themselves easy in application. Creameries, butter factories, and cheese factories abroad succeed because they are conducted under manufacturing organisation, and not by isolated domestic producers. The farmers in the United States who have entered into these combinations get about twice the price for their produce which they did on the individual system of sale, and yet compete with our home producers. It is true that certain qualities of products may best be obtained in isolated farms. Thus, cheese in Somersetshire of the highest quality may fetch 80s. per cwt., when factory cheese sells for 60s.; but the great bulk of the consumers content themselves with the lower quality, just as machine lace suits most people, while Brussels hand-made lace still preserves its position among the rich. Farmers have been told by their leaders that a tax upon food is now altogether outside practical politics, so they must abandon the hope of relief through

protective duties. There need not, however, be discouragement for the future of their great industry, if they would recognise the fact that they, like farmers abroad, must act in combination, and cease, for the bulk of their produce, to carry on domestic production as isolated individuals.

In prosperous times few inventions or improvements are made, while in bad times they arise quickly. Let us hope that we shall not continue to spend not much less than seventy millions annually on foreign food, when, by combination and modern machinery, much of this could be produced at home.

I now pass to the consideration of the economical application of machinery and of inventions upon manufacturing industries. The quantity and quality of products have been greatly altered, and this, coming at a time when the means of distribution became so extended and cheapened, produced a surplus of commodities beyond the immediate wants of the world, and, as a surplus determines price, lowered that for every staple commodity. As the margin of profit became less, a demand for greater economy in production arose, so that machines were invented to produce with the minimum of human labour. By these inventions a great amount of old forms of labour were displaced, and higher forms came into demand. I have given illustrations of this displacement of labour in the article which precedes this in the series, and many others might be given, though they all possess common characteristics. Sometimes the displacement of labour is enormous, as when the cotton-gin, worked by one man in its most improved form, does the work of one thousand manual labourers; or, when the bobbin-net machine is supposed to have a six-thousandfold greater production than hand-labour. Those are extreme instances of displacement of hand-labour by machinery, but it would be probably below the mark to put the displacement on an average, since 1873, from 30 to 50 per cent. of hand-labour. Every invention produces

social change and dislocation of labour. The application of the invention demands higher intelligence in labour, so the labourers of low intelligence go to the wall, and we are familiar with them under the name of the "unemployed." These flock to London, and find it still more difficult than in the provinces to obtain employment for their unskilled labour; so they become an incubus on the metropolis.

It is the essence of invention to displace unskilled labour, and to replace it by machinery. Ultimately the change is beneficial to humanity, for the sweat of the brow and the mere labour of the body are relieved by the intelligence of the brain. Let us clearly understand the change which is passing over industry in regard to the two kinds of labour, that of quantity and that of quality. The labour of quantity is little more than brute animal force, which is continually decreasing in value as a factor of production. With efficient training in gymnastics it would be impossible to toughen the muscles of workmen more than those of Greek athletes, and we do not care for this result, for Nasmyth's hammer will do the work of a thousand athletes. The labour of quality, or labour carried on and directed by skilled intelligence, is rising in value as the second factor of production. As invention advances, the steam-engine in the basement of the factory pushes aside the labour of quantity, or the brute animal force, while the men, women, and children upstairs supply the labour of quality, which requires observation and intelligence, qualities which have not yet been imparted to machinery. In a few exceptional cases a machine may become nearly automatic, like the cotton-mule, which leaves little for intelligence, though a good deal for observation in catching and mending the broken threads. All machinery, in fact all inventions, tend to progress from complexity to simplicity. Remember Charles Lamb's story of Hoti and roast pig. The division of labour in tending a machine is apt to be condensed or

simplified, and therefore the workmen require a superior and versatile intelligence to be able to adapt themselves to the changes which constantly arise in the economy of labour. The inspectors of factories, in their last report, mourn the fact that children are lessening in the factories. To me this is a subject of rejoicing, as it indicates an advance in the social condition of the people. From the beginning of the 1874 depression, children in textile factories have decreased by 34,000, but, on the other hand, the adults have increased by 65,000. The labour now requires more skill and intelligence than uneducated children can give to it.

I need scarcely tell you that this cold-blooded discussion in regard to labour of quantity and labour of quality gives little sympathy to the unemployed. Science is essentially colourless and impersonal. Since I began my addresses on the subject of the depression, I have received many letters from unemployed labourers. They tell me that their lamentable condition is due to machinery, and some of them have proposed that I should organise, and even become a president of a European association for the destruction of machinery! They point out that the unemployed armies of Europe might be used for this purpose with economy and advantage to labour. Ah! gentlemen, do not laugh: these labourers of quantity are in this condition because they have no educated intelligence, and until they obtain it, many of our people must remain low in the scale of civilisation, for they do not possess that labour of quality which is essential to give them entrance into the new forms of production. Labour may be displaced so rapidly that the industries of a nation may actually perish. You recollect that the Moors were wonderfully intelligent labourers, skilled in science and art, and they raised Spain to be the envy of European nations. The Inquisition, in the time of Philip III., insisted that they should be expelled as heretics from Spain, and they were banished in a barbarous manner. They had been

excellent cultivators of the soil, and expert artificers. On the expulsion of the Moors, the cultivation of rice, cotton, sugar, and the manufacture of cotton, wool, and silk goods rapidly dwindled. The 16,000 silk-looms of Seville fell to 300. Toledo had 40,000 workmen engaged in silk industries, and lost their labour. Burgos, the most famous town for manufactures, continued to exist only in name. The labour of quality had been displaced from Spain by the ruthless expulsion of the Moriscoes, and nothing remained but the labour of quantity. The result may be given in the words of Froude:—"The Spaniard's intellect shrivelled in his brain, and the sinews shrank in their self-bandaged limbs." This was the cause of England developing into a manufacturing nation, for our manufactures expanded as those of Spain contracted. The cotton industry had been introduced into Spain as early as the tenth century. It practically passed over to England on account of the great political crime of the seventeenth century. It has been the good fortune of this country to benefit by the political crimes against liberty committed by other nations. The expelled Flemish Protestants and the French Huguenots developed our woollen and silk industries. A feeling is growing, especially in the metropolis, against the importation of foreign labour, but we ought to watch this with jealousy, even though a committee is now engaged with its consideration in the House of Commons. In the historical cases which I have cited, foreign countries suffered because they displaced their skilled, intelligent labour. Our late depressions have resulted from the very opposite cause—that unintelligent labour has been displaced, while skilled labour remains in employment. There are rare exceptions to this statement. Thus Bessemer's steel substituted the use of bar iron, and 39,000 skilled producers of that manufacture lost their employment; but because they were skilled, they quickly became absorbed into the new industry. More

usually when industries decline in this country, as in the case of the silk trade, the reason is that the manufacturers have not kept up the labour of quality in competition with foreign countries. Thus when Coventry, Macclesfield, and Spitalfields were declining in silk manufactures, Basle, in Switzerland, and Crefeld, in Germany, were rising, because they established complete systems of technical education for their artisans. Where we have enterprising manufacturers like Lister of Bradford, with technical schools such as they have in that town, the silk industry maintains its ground.

The effect of inventions upon the rate of wages of labourers is decidedly to raise the wages of those who are able to carry on the industry under the new conditions. Machine hands are better paid; manual labourers are worse paid. Mr. Lakeman's recent report on female labour in London shows this in a striking way, though it is true universally. The factory workers are both better paid, better cared for, and more moral than manual workers carrying on the same trade without machinery. Wages depend a good deal upon the social condition and wants of a community. Machine-producing countries give high wages to their workmen, but the products made represent in exchange much more labour than in countries which depend on manual labour. Thus, one day's wage of an English workman will buy as much coffee in Java as could be produced by forty days' labour; as much tea in China as costs seventy days' labour, as much sugar in Cuba, or hemp in Manilla, as is equivalent to seventeen days' labour; and as much wool in South America as equals seven days' labour. High wages in machine factories mean a low cost of production, and low wages in hand industries mean high cost of production. Take as an illustration the manufacture of watches by machinery. A skilled girl can earn 36s. or more, weekly, by putting the wheel into watch cases. She can insert 1,600 daily (having to handle four pieces in

each operation—the wheel, two washers, and the pinion wire). The whole watch consists of fifty-eight pieces, requiring 370 single operations. All the workers have high wages, but the watch is sold at only ten shillings. In England the wages of working men are higher, and their hours of work less than those of similar industries on the Continent; though at the same time they produce cheaper things. If we compare the wages of our skilled mechanics with those of the United States, which manufactures under heavy protective tariffs, there is little reason to regret our position, and none at all to attribute our lower rate of wages, as compared with America, to Free Trade. In these two countries the social wants and condition of the people are nearly identical. If the people chose to go back to the time of leather breeches and coarse fustians, and were content to live in rude huts without window panes, their wages would be small, but they would be earned with a much simpler trade organisation. In the United States, and in the United Kingdom, the social demands are high, and so are wages. The increase of average wages for mechanics in the former country between 1850 and 1886 is stated to be 9s. weekly; while in the United Kingdom it has been 8s. 5d. As the necessaries of life are not taxed in this country, the purchasing power of the lower sum makes our increase the greatest. Between this period Mr. Atkinson has shown that the common labourers can buy 66 per cent., factory operatives 78 per cent., and skilled mechanics 90 per cent. more of the necessaries of life with a single day's wage. The Bureau of Labour gives the average weekly wage of the American mechanic at 43s. 4d., as compared with 29s. 10d. for the English mechanic. In both countries food can be obtained for the year by the same effort—viz., 113 days for the British workman, and 114 days for the American. In this respect both are in a better position than workers on the Continent, as it requires the wages of

120 days in France, 133 in Belgium, and 150 in Germany to obtain food for the family. If working men are good at their craft, there is no doubt that high wages mean cheap things and lower wages mean dear things. If it were not so, how could it happen that with wages 84 per cent. higher in England than the average for the whole of the Continent, the general cost of production in this country is at least 30 per cent. less? If this were not so, England would cease to be the great trading nation of the world. The explanation of this is, that the use of steam machinery in this country is 117 per cent. greater than on the Continent. If we are to continue this prosperity it must be by raising the amount of the labour of quality, which can only be done by giving to workers a trained intelligence in regard to their work.

By the observations which have preceded I desire to convince you that the continued depression of fifteen years has nothing whatever to do with our Free Trade policy. The real cause may be summed up in a single sentence—that the world has not yet accommodated itself to the wonderful changes which science has produced in the modes of production and in the exchanges of commerce. If you accept this conclusion, I have little to say in regard to Free Trade, the principles of which you understand as well as I do. England, for the last fifteen years, has had her share, but not more than her share, in the depression produced by this transition of trade. Her unemployed have been fewer, and her labour disturbances or strikes much less frequent and acute than in the United States with its policy of Protection. The reason for the difference is that our Free Trade policy leads to a large export trade, which carries off the surplus of manufactures; while the Protective policy of the United States limits her exports to a great extent to food stuffs, and prevents her manufactures meeting us in the markets of the world. Notwithstanding this fact, the United States is

really a great manufacturing nation, with a population industrious, educated, and inventive; but her fiscal policy cramps her development. She tries to compete with us in foreign markets, though with small results. In China, English imports amount to 28 per cent. of its total imports; those of the United States to 4 per cent. To South American States we send from 28 to 39 per cent. of their imports; while the United States send only 7 per cent. Even to Japan, though geographically so well placed on the Pacific, the United States send but 7 per cent. and England 43 per cent. of the imports. The tariff wall is so high in the United States, that their own exporters get over it with difficulty; while, in spite of its height, our merchants send into that country nine times more manufactured goods than she sends to us, although our ports are free. The prosperity of the United States is owing to her immense territory, with its rapidly-increasing population, which has jealously preserved internal free trade throughout all her thirty-eight States, though she shuts out external trade by high protective duties. The absurdity of this system in America is its assertion of the principle that scarcity is better than abundance in its dealings with foreign States. The wealth of nations as well as of individuals is described in the Proverbs:—"There is that scattereth and yet increaseth; and there is that withholdeth more than is meet, but it tendeth to poverty." In one sense I am sorry to say the people on the other side of the Atlantic are coming to our view of Free Trade more rapidly than is for the interest of England. Let me quote from the speech of Mr. Hurd at the Free Trade Congress in Chicago:—"You ask the reason that so many workmen are out of employment. Why, because our mills are idle from there being no demand, and this absence of a demand results from the so-called over-production, which is only another term for 'no export markets,' caused by the absence of foreign trade, which

the selfishness of protected manufacturers prevents." One more quotation only, and it is from the late Secretary Manning, of the Treasury at Washington. He is still more pithy :—"While our tariff encumbers with clumsy help a few thousand employers, it has trodden down the millions of wage-earners." The whole truth lies in this, that the policy of the United States retains the market for its own 60,000,000 of people, and loses the markets for the world's population of 1,400,000,000. Some of her industries, like those of cotton and wool, are already producing a surplus which the home market cannot absorb. They will soon pass to the side of Free Trade. Let us get ready for the fierce competition which will follow when the scales fall from the eyes of our kinsmen on the other side of the Atlantic. You will readily comprehend from my argument in what manner we must prepare to keep our position in the increasing struggle of nations. We must give more of a trained intelligence to our producers, intelligence to the rank and file, high technical education to the officers of our industrial armies. What is technical education? It is simply the *rationale* of expert empiricism. We must convert, as much as we can do, labour of quantity into labour of quality. We now know with tolerable certainty the conditions which produce low wages, and those which produce high wages. Our interest as a nation is to aim at the latter. What class of labourers produce dear things? They are ignorant labourers with faint ambition, who are badly housed, badly clothed and fed, who have few pleasures of the mind, and who trust to the Poor Law to stand between them and starvation These are the labourers who are content to work for low wages, but the product of their labour is low and its cost is high. What class of workmen produce cheap things? They are the working men of technical skill and trained intelligence who seek more education for themselves and children, because they know

that it both dignifies and fructifies their labour. They are men who by combination have raised their position and shortened their hours of labour, so that they may enjoy some of the pleasures as well as take their share in the toil of the world. They hate the workhouse as much as they hate that kingdom over which the devil is supposed to reign. Their wages are high, but so is their productiveness, and consequently they give us our cheap things. They are the men who are the props of our industries. Though their wages are high, they are cheap at the price. Protection is not a force to raise wages. If it were they should be high on the Continent of Europe. The interest of a labourer is to sell his labour dear and to buy his commodities cheap. Protection enhances the price of the latter; but how can this benefit the labourer? Though the labourer does not gain by Protection, the monopolist does, and it is he who is encouraged and over-remunerated by high tariffs. England has abolished monopolies and refused to support privileged classes by taxation. She is a country small in area and limited in population, but great in productive energies. She is a world-wide trader, because her manufacturers can barter on advantageous terms with other nations which seek her free ports for the disposal of their commodities, and are forced to accept English goods in exchange. The industrial prosperity of England is as much due to commercial freedom as the social condition of her people is due to their political liberties.

> "For what avail the plough or sail,
> Or land or life, if freedom fail."

THE EFFECT OF PROTECTION ON WAGES.

Speech delivered at Leeds, 1 Dec., 1888.

I HAVE lately returned from the United States, where a very important issue has been before the people during the Presidential election. It would be false to call that issue one of Free Trade, because the proposal was whether the high Protectionist tariff, now averaging 47 per cent. on the price of imports, should be reduced to 42 per cent. If a man took forty-seven drinks in the day and reduced them to forty-two, you would not call him a teetotaler; so a small reduction of a high tariff cannot be dignified as one of Free Trade; but it is the thin end of the wedge, and may be driven home so as to rend in twain the system of Protection. The real question before the people was whether Protection is the source of high wages among the working-classes.

You are aware that wages in America are notably higher than they are in this country. This is generally but not invariably true. Nominal wages mean so many dollars or shillings per week, while real wages are the necessities and comforts which can be bought by them. Let me give you a concrete illustration. I know the case of three men who emigrated from Bradford to America. They earned 32s. in this country, and went under an engagement to receive 50s. in the United States, where they have been for two years. About six weeks since they wrote to their old English master offering to come back at their old wages, because they found

these went farther in England than their higher nominal wages did in America. Upon hearing what they had done, their American employer raised their wages to 56s., and they remain to see whether this will render their position more favourable. In considering my observations, bear in mind the important difference between nominal and real wages. What makes nominal wages higher in the United States? The real wages of unskilled labourers are certainly higher in that country, but I am by no means so certain that those of skilled workmen are.

There are two great political parties in America—the Republicans and the Democrats. The former support Protection, and contend that wages are raised by this system and maintained at a high level. The Democrats, in the late contest, have with some misgivings now ranged themselves in favour of a reform of the tariff, and they deny that Protection influences wages in any sensible degree. Protection, say the Republicans, creates industries which would not exist without it, and therefore it gives work to labour. It is not work for itself that the labourer desires; he wishes to obtain a comfortable living from his work. He does not live to work; he works to live. Good living at the lowest price is the workman's aim. How can taxes on most of the necessaries and upon all the comforts of life help him to that end? When taxes, averaging about one-half the value of commodities, are put on foreign imports, home-made goods must rise to the increased selling price, otherwise Protection would neither have meaning nor justification. It is obvious that, under these conditions, each man as a consumer pays a tax to himself as a producer. You work in a woollen mill under this Protection, and are gratified that the toolmaker, the shoemaker, and hatter pay taxes for the support of your industry; but they are consoled because you pay taxes to support them in their trades. This is a vicious circle, and you might as well transfer money

from your left to your right pocket in the vain hope that you are enriching yourself. If Protection gives to a man more wages, where does the *more* come from? It comes from the taxes, which all working men have to pay to support Protection.

A little consideration will convince you that Protection has nothing but a deteriorating influence on the rate of wages. In the first place, the unprotected industries in the United States have higher wages than the protected trades. The carpenters, who have no Protection, make £90 yearly, while the protected cotton spinners and weavers get £49. The unprotected bakers win £84, while the protected makers of men's clothes get £57. The free printers obtain £118 in wages, but the protected machine makers have only £91 wages. The workers in stone and marble have £91 wages; but the closely protected industries of iron and steel average £78. These are the averages which I take from the returns in the census, and they might be largely multiplied. They are conclusive as to the fact that the wages of protected industries are lower than those which have no Protection from the tariff.

Still you may think that Protection must at least regulate and render uniform the wages of like industries all over the country. It does nothing of the kind. The variation between the wages of the same industries in different parts of the Union is greater than between it and the United Kingdom. Ohio and Connecticut are states with woollen manufactures, but the wages vary by 70 per cent. New Jersey and North Carolina have cotton mills, and their wages differ by 80 per cent. Now, the alleged difference between the wages of America and England is generally taken at 50 per cent. Observe, then, that Protection neither ensures the highest wages to its industries, nor does it equalise them in the same trades. That wages are not governed by Protection follows from the fact that they are

no higher under an industry protected by 100 per cent. duty than they are under one having only 25 per cent.

The most serious evil of Protection in America is that it practically restricts the markets for manufactured goods to the domestic demand of its population of sixty millions. This, no doubt, is a large market, but it is not nearly so large as the market of the world. The exclusion of foreign markets produces a constant glut of commodities, and many mills make in seven or eight months as much as they can sell in twelve; so they shut up for three or four months in the year. Of all material evils insecurity in the means of living is the most disheartening, the most exasperating, and the most demoralising to working men. An enforced idleness for a third or fourth of the year is disastrous to working men. It means seven months' pay for twelve months' living. I quote, as an illustration of what is constantly happening, a single paragraph from the *Boston Post* of 10th November: —"The carpet mills of E. S. Higgins & Co. gave notice of a reduction of 600 men from Monday next. At Reading to-day the ironworks were shut down for an indefinite time, and 300 men and boys were thrown out of work. The Boston sugar refinery will be closed to-night for an indefinite period. This refinery reduced the wages of the workmen 7 per cent. on October 1st." Periodical stagnation of this kind must be hateful to working men, who like steady and continuous labour. In 1885, of 816,000 operatives in Massachusetts, 241,000, or 29½ per cent., were out of employment in this way for part of the year. In the cotton mills, 39 per cent. males and 43 per cent. females; in the woollen factories, 39 per cent. males and 45 per cent.* females; and in the boot and shoe machine shops, 67 per cent. males and 71 per cent. females, had these stoppages in

* David A. Wells—"Relation of the Tariff to Wages," p. 42. Fifty-six other occupations were enumerated in this State, of which half the whole number were idle part of the year.

their annual work. The nominal high rate of wages thus suffers a serious reduction. Except in the face of grave depressions of trade, we do not experience this evil in England, because the cheap cost of production enables our goods to be sent to foreign markets, although the domestic market may be glutted by over-production. The autumn steamers bring back to England many of these idle workmen. They come to England to spend the three months when there is no employment for them at the mills, because they may get work here; and even if they do not, it is much cheaper to live here, and they return to America in spring to get their high nominal wages when the factories are again open.

The Republicans assert that Protection is necessary for the employment of native American labour. The real truth is that protected factories now employ few Americans. In a large mill in New Hampshire, employing 6,000 hands, only 230 Americans are found among them: the rest consisting chiefly of French Canadians, a good many Irish, with a few Germans and English. You have lately heard a good deal about the fisheries, which are now straining the relations between this country and the United States. These fishing vessels sail from the coasts of New England to fish on those of Canada, and it is contended that they must be protected, because they are the chief nursery for American seamen. In these fishing vessels there are only 25 per cent. of American seamen, the remainder of 75 per cent. consisting of Canadians and English sailors from New Brunswick and Nova Scotia. I state this on the authority of the chairman of a Committee of the House of Representatives, which has been appointed to inquire into the fact that Americans are so rapidly lessening in the protected industries. The causes of this diminution are not far to seek; they are due to the circumstance that native Americans desert protected industries, which are constantly lowering wages owing to

the pressure of competition in a limited market, and they pass over to the unprotected labour, which is better paid.

Allow me now to give my reasons for the general fact that Protection not only fails to maintain good wages, but that it is a force, and a strong force, to lower them. Buyers and sellers are correlative. If a man cannot sell his labour for the whole of the year, he cannot buy manufactured products when he is idle, except by stinting his purchases, and encroaching on his savings to purchase the actual necessaries of life. When mills stop for some months in the year, the workmen become poor and discontented. This leads to the strikes and depressions which are so painfully frequent in America, and about which I shall have something to say later on. In the mutual dependence of buyer and seller, the American workman sells his labour under conditions of Free Trade, because there is perfect Free Trade in the thirty-eight states and eleven territories of the Union, but he buys his commodities under Protection. The workman as a buyer cannot get any foreign manufactures except at a price 50 to 70 per cent. higher than its cost in Europe, while the home manufactures, except when there is a glut of them, are sold at a price which represents the duty of the tariff added to the production. These high priced goods largely lessen real wages, which, as I have explained, are the amount which you can get for your money in providing the needs and comforts of life. This lowering of real wages is represented in a concrete form by the higher price of all protected commodities, whether they are imported from abroad or are made at home. Taxes thus laid upon labour come out of the pockets of the people, and have exactly the same effect as if you made a direct deduction from the power of tools, from the fertility of the soil, or the capacities of the climate. You must then see that Protection is a force which cuts down nominal wages, and that the high cost of production caused by them forces

the competing manufacturer either to lower wages or to seek for cheaper labour from the foreign emigrants who flock to America from every other country:—

> "Great Empire of the West,
> The *dearest* and the best,
> Made up of all the rest."

I have denied that Protection determines the high rate of wages in America, and I must now explain what causes it. Why are wages higher there than in England? Cobden explained the condition of wages in a single sentence. "When two men ask work from one employer wages are low; when two employers are after one man wages are high." This is the law of supply and demand, and it rules wages in America as it does in England. In the United States there are only fifteen persons to a square mile, while in England and Wales there are 446. Sir Walter Scott said—"Whenever a Scotchman gets his head above water he makes for the land." The very reverse is true as regards America, for whenever the labourers of any nation in Europe get their heads below water, they strike out for the prairies of America. The land of that country now requires eight millions of labourers to cultivate it, while those in other industries amount to about three millions. These are only partly under Protection—the general estimate being that there are from seventeen to twenty unprotected labourers for every one who is working in a protected industry. In order to be on the safe side, let us put the proportion as ten to one. Is it not obvious, when the unprotected industries compete for ten men, and the protected industries for one, that it must be the former and not the latter which determine the rate of wages? Of the unprotected industries, agriculture is much the most important. Out of seventeen and a-half million breadwinners in the United States, the land employs eight millions; so that is necessarily the

by 62 per cent., while Free Trade New South Wales has grown by 139 per cent., and now pays wages which are even higher than those of the United States. The male wage-winners of Victoria emigrate to the neighbouring Free Trade colony, and the Protectionist colony has now an excess of female labour. The wages of a man in Victoria being £83, if he pass to New South Wales he gets for the same work £100.

Senator Sherman, a politician of mark in the United States, is agitating the American people to annex Canada, and sever it from England. Vast as is the territory of the United States, and rapid as is the growth of its population, which ought to count two hundred millions in another thirty years, it is not vast enough for a system of Protection relying on home markets for the disposal of its products. So its politicians want Canada, a country about the same area as the United States, now thinly peopled, but

with great potentiality of growth. The annexation of Canada, either by negotiation or by force, would wound our national pride, but would it wound our commercial supremacy, as American politicians believe? Its effect upon the whole continent of North America would be to keep up nominal wages over that vast area for another hundred years, and to exclude it still more effectually than at present from the foreign markets which buy our manufactured goods. How wise are statesmen in their generation!

Perhaps you are not yet convinced, and wish me to explain why it is that extensive emigration goes to America if Protection does not keep up wages. No doubt Protection stimulates emigration, but not in the way which its advocates believe. The chief emigration to America is from countries of high Protection, which, by lowering wages, drive out their working men. China is the father of the protective system, and Chinese labourers swarmed to the Pacific coast until their influx was prohibited by law. It is the protected countries of Germany and Italy which send out the bulk of emigrants to America. The country which sends out fewest is Free Trade England. From 1880 to 1887 highly protected Germany sent out 1,235,926 emigrants, or 29 per cent. of the whole number; while England and Wales supplied 496,037, or 11½ per cent. Ireland, during that time, sent out 534,691 emigrants, or 12½ per cent., and you know the causes which make Ireland unhappy and discontented. If Protection is a guarantee for high wages, why did protected Germany send out nearly three times as many of her people as Free Trade England? Very few of our skilled labourers emigrate from Great Britain, because for them real wages are not very different on either side of the Atlantic. Unskilled labourers are wise to emigrate, as the demand for them is greater than in this country, and the real wages are higher. It is not Protection which to any considerable extent beckons the

labourers from other lands. In the last ten years, excluding the women and children, only 2 per cent. of the emigrants went into protected textile and metal industries, and another 2 per cent. into mining.

As we are dealing with the effect of Protection on wages, let me interpolate an observation in regard to European countries. The low-priced labour of Russia seeks to protect itself by a heavy tariff against the higher wages of Germany. Italy, with its badly paid labour, desires to exclude the German goods. Most of the European countries unite to protect their cheap labour by high tariffs against England, where the average wages are from 80 to 100 per cent. higher than on the Continent. Mistaken as to their means, we still recognise a general purpose that it is well to protect the weak against the attacks of the strong. But Protection in the United States is the very reverse of this, for there it is a case of the strong trying to protect themselves against the weak, the high wage-earners endeavouring to shut out what their politicians call "the pauper labour of Europe."

I come back to the comparison of American and English wages, and will try to explain myself more fully. It is almost impossible to compare rates of real wages between two countries, as the conditions vary materially. Blaine, the leader of the Republican party, tried to do so when he was Secretary of State, by getting excellent consular reports from different parts of England. I give the conclusion in his own words:—"The hours of labour in the Lancashire mills are 56; in Massachusetts they are 60 per week, and in the other New England States, where the wages are generally lower than in Massachusetts, they are 60 to 69 hours per week. Undoubtedly the inequalities in the wages of English and American workmen are more than equalised by the greater efficiency of the latter and their longer hours of labour." During the election, the Protectionists posted a placard in the chief mills and workshops of New York, giving the

average wages of seventeen staple industries in various countries. I give you the comparison for what it is worth, as I have no means of testing its accuracy. The wages in Germany are given as 14s.; in England at 30s. 8d.; and in New York at 49s. 6d. Let us draw our own conclusions from this Protectionist statement. Wages in these seventeen staple industries are 111 per cent. higher in Free Trade England than in protected Germany, though they are 61 per cent. higher in America than in England. On the other hand, the latter figure represents the average amount of 50 to 70 per cent. levied by taxation upon manufacturers. Wages are not measured by money, but by the worth which can be bought by it. Another estimate of American and English wages has been made by Caroll Wright, the head of the Labour Bureau, and, whether he is right or wrong, his calculations are painstaking and honest. He says that a Massachusetts mechanic with a wife and three children, two of them working, makes in a fully employed year £160; while the English mechanic, under like conditions, makes £103. But it costs the American workman, according to the same authority, £151 to live comfortably, and the English operative spends only £101. If this comparison be true, at the end of the year the American mechanic will have saved £9, and the Englishman only £2. Recollect that the latter has less work per week to the extent of four to six hours. I have looked to the savings banks to test this estimate, but they are only one method of ascertaining the thrift of a whole people. Building societies, prudential associations, and other agencies for promoting thrift complicate the question. Taking all the people of the United States, their deposits in savings banks are £4 per capita, while in the United Kingdom they are £3. The latter sum has in this country more purchasing power, so that the savings of the working classes in the two countries may be considered equal.

It is the custom of American politicians to magnify the efficiency of their working classes as a contrast to the worn-out and effete people in Europe, especially in "decrepit old England." Thus it is said that, while an English operative can only manage three looms, an American undertakes five or six. I think, for the same class of work, American managers get more work out of their men than English do, for the discipline of the workshops is more severe. Usually, however, the comparisons are made upon incomparable conditions. The cotton operative here is usually engaged on a fine class of goods, when his American brother chiefly produces coarse fabrics. In England cotton is dear and labour is cheap, so we use more labour and less cotton than they do in America. Besides, an operative in their mills will turn out more product when he works from four to ten extra hours per week. I have told you that native Americans are disappearing from the mills; so the comparison is not between American and English operatives, but between untrained French Canadians and Irish, who take their places, and the trained English worker in his own country, and how the latter can be inferior to the former passes human comprehension. The real American working man is a most efficient operative; but that he is better than a good, honest English artisan I could not find out in my investigations. I must conclude this part of my observations by asking your assent to my conclusions, that Protection makes a gigantic error when it claims to be the source of high wages.

"Wheresoe'er I turn my view,
All is strange, yet nothing new;
Endless labour all along,
Endless labour to be wrong."

Recollect that I have been discussing the effect of Protection not on infant but on matured industries. I do not here care to deny, though I do not admit the argument, that

protected infant industries, when first initiated, may enhance wages and profits. Even if it were necessary to attach a third horse to pull a load up a hill, it is too costly to continue it when you reach the level. The evils of Protection become more palpably manifest when infant industries have grown into maturity and produce glutted markets by excessive competition. Then the evil of Protection shows itself by low wages, strikes or lock-outs, and periodical stagnation, resulting in the destruction of the weak and the survival of the fittest.

I now direct your attention to the Trades Unions in America. In the acute year of depression, 1884, the reduction of wages was chiefly in protected industries. In cotton and woollen mills it was from 20 to 30 per cent., while there was no lowering in the wages of unprotected house builders, carpenters, stone cutters, and brick makers. In the protected iron industries wages fell from 15 to 22 per cent., but the unprotected butchers, bakers, millers, tanners, and printers did not suffer. Wages in the protected silk mills fell 15 to 25 per cent., though those of labourers on the land were maintained at their old rate. Trades Unions cannot regulate markets, but they are useful in getting the benefit to the labourer when they improve. Even in years of prosperity, strikes—the last resort of workmen—are painfully frequent in America. In 1887 there went out on strike 340,854 persons, and of these 112,317, or about one-third, were in Pennsylvania, a State in which the highly protected iron industries are situated. From 1881 to 1886 no less than 1,323,203 workers were out on strike, and their loss in wages, according to the report of the Labour Bureau, was twelve and one third million sterling. Putting the complete and partial successes to the credit against the failures, a gain of average wage of one shilling and a halfpenny per day was achieved; but to obtain this the whole of the strikers would have to work ninety-nine days before they

covered the loss during the strikes. This uneasiness of labour, which has been marked for some years, led to the formation of a gigantic organisation called "The Knights of Labour." The bread-winners of the United States number seventeen and a half millions, and of these this organisation claims that it enrolled from one and a half to two million members. Its aims were much larger than those of Trades Unions. The latter have been an important educational force in the industrial life of England, and have raised the level of conduct and political ability of our working men. Even in our past history there have been no doubt instances in which Trades Unions have been wild and irrational in their means and ends; but as they got experience and education, the relations of the employers and the employed became more harmonious, while the acts of our unions in asserting fair and just consideration for the claims of labour became more temperate, steady, and wise. The American Trades Unions have not yet won this experience. They scarcely existed before the war of secession, and they are still noisy and irrational in their ways, which are neither so effective nor cleanly as with us. The Knights of Labour arose to make them all-powerful. Many Trades Unions merged themselves in this organisation, and gave up their self-government. It was a huge confederation of labour, and aimed to subordinate all local and special interest in a centralised government. It grew with amazing rapidity, and showed so much political power that, as General Walker, the distinguished American political economist, remarks, "it goes without saying that the politicians grovelled, as only American politicians can grovel, before all who were supposed to exercise influence among the Knights of Labour." This organisation asserted its right and power to transfer the whole initiation of production from the employing to the labouring class. No employer could, under such conditions, enter into contracts or extend his business. The huge force

of the new confederation was to be thrown in favour of local strikes, while boycotting and other means of pressure were to be unsparingly used. This tyranny at one time seemed as if it would prove intolerable, and thoughtful men looked with alarm to a wholesale destruction of wealth, and to the general prostration of industry. The Knights of Labour have dismally failed. Their one and a half million of members have shrunk to 200,000 in the few years of their existence, and now, even among American politicians, there are none so poor as to do them reverence. The Trades Unions have withdrawn from the confederation and resumed their former autonomy. In condemning some of the ways of Trades Unions in America, such as the outburst of lawlessness in the middle States in July, 1877, we must not forget, in extenuation, that, in good times, protection brings excessive profits to a few capitalists, while to an undue extent it throws the burden of bad times upon the wage-earners.

All political economists now agree that high-priced labour produces low-priced commodities, while cheap labour means dear goods. This is now understood by most trades, but not by all. In the black country round Wolverhampton the manufacture of nails and chains is still a domestic industry, carried on in the house of the workman, with the most primitive machinery, like a hammer called "the oliver," which is an instrument of home construction fearfully and wonderfully made out of old bedposts or other ready contrivances. The wages of the workers are deplorably low, yet the peaceful, orderly population work on with the hope of improved times, although factories, with machinery conducted by labourers highly paid, are destroying the domestic trade. The machine-made nails from America now push hand-made nails out of the market. In factories run by machinery the labour cost in the finished product is small, varying from 15 to 21 per cent. of its cost. You will readily understand this because there are fewer workmen to the product,

although their wages are high. Though the cost of the sum of labour in a machine product is low, its cheapness is compassed through high wages. The skilled English workman has no fear of low-priced inexpert labour, but he does fear high-priced expert work. The high wages in this country are not lowered by the low wages of the European Continent. Yet it is this "pauper labour of Europe" that is used in America to stalk as a spectre round the ramparts of Protection—a grim sentinel to scare the working men. The employer as well as the employed now know that Adam Smith was right when he said that high wages produce more active, diligent, and expeditious work than when they are low. Wages are really a share in the product of industry, and must ultimately be determined by the value of the product in the markets of the world. When a working-man in Free Trade England has earned his wages he can spend them on untaxed commodities, with the exception of a few necessaries such as tea, or some luxuries like spirits and tobacco, which contribute to the imperial revenue. The working-man in America finds himself face to face with taxation in every act of his life. Henry Philpot, a farmer's boy, describes his own experience as follows:—"When I rise from my humble cot in a log farm-house, throwing off my bed-clothes, taxed 40 to 100 per cent., and putting on my clothing, taxed 35 to 100 per cent., I eat my breakfast from dishes, taxed 45 per cent., on a tablecloth, taxed 40 per cent.; and when the Sabbath bell, taxed 35 per cent., sounded its inviting notes, I took my Bible, taxed 25 per cent., and went to the church built of lumber, taxed 20 per cent., and there I sung from my hymn-book, taxed 25 per cent." It is surely needless to explain more fully than I have done that high nominal wages are not real wages in a protected country.

The last experience which I derived from my study of the effects of Protection may surprise you. It is that

Protection leads slowly, but surely, to Socialism, and tends even to Communism. There are certain Socialistic aims that all but the *laissez faire* politicians approve. The State ought to be empowered by health, factory, mining, and education laws to secure for the people an unmutilated and undeformed manhood, or, in other words, to preserve by public means the conditions for a humane existence in a civilised country. That common and limited Socialistic action of the State is very different from that which unwisely intervenes to save individuals from the labour and struggles of their daily lives, by taxing all of us to compensate for the deficiencies or idleness of some of us. If a State, through protective laws, can say that some of us are to be taxed, not for the security of all of us, but for the exclusive benefit of those who are monopolists or manufacturers, in order that they may obtain steady and large profits, on what principle can the latter object, when the working men, who have the controlling power in politics, turn round upon them and say, "You have taxed us to guarantee your profits, now we propose to get the State to tax you manufacturers to guarantee us our wages"? That is rank Socialism, but so is Protection. The man who asserts his right to take away some of the earnings of a working man through taxation to support the industry of another, whether he be a manufacturer or an operative, is very near being a Communist, differing very little from the man who denies the right of property altogether. It is not the way in which you are despoiled, but it is the fact that you are despoiled which constitutes the wrong. If it be right that the State should tax you because your neighbour's ironworks or cloth mills do not pay, it cannot be wrong for workmen to insist that it should provide public workshops, or to insure their lives, or promote any of the various devices which Socialists demand as a means of lessening the struggle for existence among individuals. Within the last few weeks you have seen an instance of this in France.

Protection in that country has raised the price of the loaf, and the people have demanded that a maximum price should be put upon bread, a power which French law gives to the Government. This was conceded, and private bakers shut up their shops, whereupon a new cry has risen for national bakeries. If you think my view is fanciful—that Protection leads to Socialism and tends to Communism—look at the movements in many countries under that fiscal system. Russia is honeycombed by Socialists; so is France; while Germany has passed severe laws for their repression. In the recent International Trades Union Congress held in London, it was not the British workman who talked Socialism or Communism, but the deputies who came over from the protected countries. In America, Socialistic outbreaks, supported by dynamite, have occurred, and the leaders have been hanged in Chicago. The Knights of Labour, had they been successful, were tending to Socialism in labour. Can you be surprised at it? Protectionists live on the product of the labour of others. In the United States one protected labourer is supported by a tax on seventeen unprotected. The principle of living on the labour of others is a principle which leads to great expansion.

I need not draw a moral from my sermon. England for forty years has rejoiced in Free Trade. Before that period, when she was under Protection, her working classes had few comforts of life, and were unable to lay by savings for their old age. Under Protection our industries had become stationary, though the population increased. In 1815 our annual exports amounted to fifty millions, and in 1840 they were exactly the same. Free Trade was gradually introduced, and became complete in 1856. In the next thirty years exports had mounted to 212 millions, and wages rose with the increasing trade. Between 1850 and 1883 the average increase in British wages has been about 39 per cent., while in the same period in America it has

been 30 per cent. In the prolonged period of depression from 1873 to 1883 wages rose 10 per cent. in this country; but they fell 5½ per cent. in the New England States under Protection. Nominal wages in most cases, and real wages in some, are higher in America than in England. This difference depends upon the conditions which prevail in a new and undeveloped country, but not upon Protection. American politicians are fond of speaking of "decrepit old England, with its pauper labour." What are the signs of its decrepitude? Not commerce, for that largely increases; not diminution of population, or increase of pauperism. The best test of the prosperity of a country is the rate of increase of its population, for that indicates what its industries can support. Between 1851 and 1861, when Free Trade was on its first trial, the increase of population in the United Kingdom was 5·60 per cent.; in the next decade it was 8·8, and in that ending 1881 it amounted to 10·8, or nearly double the increase of the first period. Yet Senator Fry, of Maine, a State with one-nineteenth of the density of population, and one-fourth the ratio of growth of England and Wales (3½ as against 14·4), has the boldness to assert in the Senate that our country is rapidly declining under Free Trade. There are some States in America, like Ohio, Indiana, and Delaware, which have increased by ratios of from 17 to 19; but the old-established States, like New York and Connecticut, have not yet reached an increase of 16 per cent. in the last decade. The great Protectionist State—Vermont—only increased by half of 1 per cent. Test the whole question, in any way you choose, by real wages, by savings, by commercial prosperity, by population, by reduction in pauperism and crime, and you will not find the slightest support from American experience that Free Trade is a delusion, that Protection adds to the remuneration of labour, or that it acts in any other way than as a drag upon the development of nations.

ON BI-METALLISM.

Address as Chairman of the Political Economy Club dinner at the National Liberal Club, 31st January, 1889.

BI-METALLISM is not a new demand for the currency of the world. In fact, mono-metallism does not exist. The general practice of the world is tri-metallism—gold, silver, and copper—varying in proportion according to the needs of various countries. Of course, I refer to currency, not to legal tender. Silver is the currency most widely adopted, for it is used by one thousand million people, or by three-fifths of the entire population of the globe. In the lowest stages of civilisation copper is used, because it is the most convenient way of paying the very low wages and small prices of commodities. As civilisation advances in countries like India, China, and Mexico, silver is found to be the most convenient standard, and is adopted. When a country advances in wealth and commerce, silver is too bulky for large transactions, and gold is added, frequently in bi-metallic tie with silver, as we had it in England up to 1816, when the gold standard was adopted and silver became a mere fractional coin. It is obvious, then, that nations adopt currencies which best suit the money work which they have to perform. For a great commercial nation like England our implement of exchange must be the metal which will most quickly and efficiently perform the money work.

Though barter of commodities is the chief method of effecting exchanges, there is a good deal for bullion to do in settling their balances. As transport improves, the same quantity of bullion passes to and fro more readily, and does more work. Gold thus becomes the implement of quick work. Supposing that we have a balance of exchange to

pay of £100, we count out one hundred sovereigns and transmit them to the creditor, who spends little time in authenticating the payment. If we had the option of paying him in silver, we might transmit 2,000 shillings, which would not be received with the same gratitude. The Bank of England had a run upon it in 1745, when the Pretender reached Derby, and to lose time it paid the cheques presented in shillings and sixpences; but in this case procrastination was its object. Gold is certainly the implement for quick work, even if a fixed ratio of 16 to 1 be given to silver coin. Silver being sixteen times heavier than gold for equal values, it requires sixteen times more time to count it; sixteen times more strength to handle it; thirty-one times more space to hold it: sixteen times more transport to carry it. If you legally fuse sixteen parts of silver with one of gold, which is the proposal of the bi-metallists, you are practically misapplying sixteen-seventeenths units of effort in the process of exchange by means of bullion.

Experience has shown that the French circulation suffered by excessive exportation of gold when the market ratio of value differed from the legal ratio by 1½ per cent., that is, when the value of gold became 15¾, instead of the legal ratio of 15½. Under such conditions debts are paid in the cheap metal, and gold disappears. From 1820 to 1847 the premium on gold varied from 1 to 2 per cent. In France, during the Latin Union, the amount of gold and silver coin issued depended upon the price of each metal, as, sometimes, nearly all the coin minted was made of gold, and at other times of silver. From 1821 to 1850, the gold coined was only 12½ per cent. of the whole; while from 1851 to 1870 it was no less than 90 per cent. Every bank in the country would have to reconstruct its strong rooms and tills to meet a changed currency of this kind, more inconvenient to us now with England's enormous commerce than it was in 1816, when we had to establish a gold standard.

The bi-metallists argue with considerable force from past experience that a legal ratio of silver and gold would produce a par of exchange, and that such a result would add much strength to the bi-metallic currency of nations. Even increased strength to the money implement might not compensate for the loss of speed with which the work is now performed. Currency should be nimble as well as strong. A cart-horse might be firmly yoked to a racer, and the two together might be stronger, but the racer would no longer have its quality of speed. I cannot admit the assumption of the bi-metallists that a par of exchange would be the consequence of a legal ratio between gold and silver. These metals are governed by the cost of production and the state of supply and demand, like all other commodities. Supposing that Governments established a legal ratio between the values of silk and cotton, nobody would care for it, but the demand would be regulated by the market value. A Chinese Emperor called Wang Mang proclaimed a legal ratio of value between five shells, which circulated as coins in his empire, but he completely failed. The inherent value of money is not in statute law. Good money requires no force of law to make it acceptable. Governments do not make money; they only certify its value as bullion. Law has been used to force bad or unsuitable money as legal tender, and there have been periods in history when heavy commercial disasters followed a conflict in regard to the nominal value of money, between statutory law on the one hand, and the law of supply and demand on the other.

What is money? The apostle of the bi-metallists, Cernuschi, gives a good definition, "That only is good money which will stand the test of fire, and which is worth as much as bullion when melted as it has been worth in the coin itself." This is practically true as regards gold now. Take gold bars to the Bank of England, and they are exchanged for the same weight of gold coin, with a trifling charge of a penny per ounce, which represents the interest

for the time lost in coining. Silver at a fixed ratio would not stand this definition, and therefore is not "good money." Nor could any statute fixing a bi-metallic tie make it so. If it could, why not enact the logical end of the Bi-metallists, and declare that silver be made the equal of gold, ounce for ounce, instead of the ratio 16 to 1. A market value and a legal value would still exist. About one-half the production of the precious metals is used in the industrial arts, the other half in coinage. An electro-plater can now get twenty-two ounces of silver for one ounce of gold, though he would have to pay more for it if all nations made a free unlimited coinage of silver on a fixed ratio. But there would always be a competition between industrial wants and coinage supply that would make a market value and a legal value. Under such circumstances an agio must be put either on gold coin or silver coin to represent the market rate. Even during the coinage of silver by the Latin Union, there never was a time when full-weighted coins of gold and silver circulated together at the legal ratio. When they were employed for bullion, one or other was always at premium; so there was no true metallic equilibrium. Of course I am aware that monopoly coins, often with a heavy seignorage, have had forced circulation in a country like inconvertible paper: but I speak of countries with a true bullion standard like our own, and in these gold and silver coins stood at the market premium, whatever may have been the legal ratio. At the same time, I do not doubt that combination may raise the market price of metals. There is an instance in the copper ring at the present time. The object of that ring of producers and vendors of copper is to make fortunes for the men inside the ring, to the infinite derangement of many industries; but even they do not think that the combination can last beyond a brief period. An international silver ring, backed by the Legislatures of the combining nations, may raise the price of silver and even maintain it for a period at a given ratio to gold, just as separate nations have

forced their monopoly coinage or inconvertible paper. Countries like England, which have a true bullion standard, are not likely to enter such a ring, and their merchants with their world-wide transactions would place the premium upon the gold or silver at their market value, and not at the legal ratio, even if they took coins with the bi-metallic tie.

Let me now examine the reasons which have made many earnest and thoughtful men seek for a remedy in our coinage by constituting a bi-metallic tie in gold and silver. They believe that the fall in the price of silver is due to the scarcity of gold, which has appreciated in value. They point to the fact that most commodities have fallen in price since 1873 owing to this one common cause, the scarcity of gold. If the common fall in prices is due to any one cause, it is difficult to find any other than that suggested. I have no intention of dogmatising, and denying that there may be some effect produced by the appreciation of gold, but I wish to show that there are far more potent causes than that for the fall in the prices of staple commodities. Let us understand what is meant by the term "appreciation of gold." If it simply mean that a gold sovereign in 1889 will buy more bread, beef, mutton, sugar, calico, &c., than it could have bought in 1872, I accept the term, for in this limited sense appreciation of gold and fall of prices are synonymous, and no one can contest the fact. A gold coin in purchasing commodities in 1888, gets more of them than it did in 1873, and therefore represents a greater quantity of human effort. But the term appreciation of gold is often used in a different sense, as when the bi-metallist contends that the scarcity of gold (if there be a scarcity) is the main cause of the fall in prices of commodities. The difference between the first and second definition will be apparent, because gold might be stationary in quantity and value, while the prices of commodities might fall from causes having no relation to it, and then its appreciation or power of increased purchase would

be a contemporaneous fact, but not a cause of the depreciation of commodities. Though gold has been able to buy many things cheaper since 1873, it has not been able, except in agriculture, to buy cheaper labour, for, as a fact, wages have risen in machine-using countries, steadily though slowly, even during the periods of depression. What things can gold buy cheaper? Most machine-made commodities have lower prices. In hand-labour countries neither gold nor silver can buy any wide range of commodities at lower prices than formerly. In recent years there has been a small fall in prices even in the products of hand labour, owing to the lessened demand in the periods of depression; but this is an accidental and not a general lowering of prices as in the case of machine-made goods.

Let me take three staple commodities—cotton, iron, and wheat—as illustrations of potent causes which have lowered their price irrespective of the appreciation of gold. There are three causes common to all of them: increased production by new inventions, great saving in the proportion which wages bear to the product (now generally 15 to 20 per cent. of the cost of machine-made products), and wonderful economy in their distribution. Let us begin with cotton. The application of machinery to the cultivation, harvesting, and cleaning of cotton has been so great, that while in 1873 a given amount of human labour in America produced three and eight-tenths million bales—a much less amount of labour in 1886-7 turned out six and a half million bales. A cotton-gin worked by one man can clean cotton as well as 1,000 labourers working by hand. Besides this great economy of production, cotton, as a bulky article, benefited greatly by increased and cheaper transportation by railways and steamboats. While these changes produced a large reduction in the price of the raw material, the economies introduced into its manufactured products were still greater. In 1873 spindles made 4,000 revolutions in a minute; now

they have been increased to 10,000. The progress of weaving has been very great. When I lived in Lancashire forty years ago, a weaver working thirteen or fourteen hours in the day could produce about 10,000 yards of standard sheeting in the year. A clever weaver now, working ten hours daily, can turn out 30,000 yards. So much has productive power increased that a single operative working for a year in a first-class mill can now clothe 1,600 fully clad Chinese, or 3,000 half-clad East Indians. This increase and economy of production lead to over-production, and a glut of the market necessarily lowers prices. In the last fifteen years the population of the world has increased by about 16 per cent., while the increase in the production of cotton goods has amounted to 86 per cent.

Let us turn to iron, the price of which has greatly fallen since 1873. Formerly England was the world-producer of iron. After 1870 other nations became competitors. Between 1870 and 1883 England increased her production by 143 per cent., while the competing countries augmented their output by 239 per cent. In 1870 the labour of an English workman produced 173 tons of iron; it now makes 261 tons. Bessemer's steel was in its infancy in 1873, and its price was £14; it has now fallen to £4. Has the appreciation of gold knocked down the humbler metal iron? The reduction in price is chiefly due to improved production. In 1873 it required double the number of men to produce a ton of steel than it does now, and 10,000 lbs. of coal were used to make a ton, while now 5,000 lbs. suffice. Surely these changes and economies of production are potent causes in lowering the price of iron without attributing it to the alleged scarcity of gold.

Lastly, I turn to wheat, the stronghold of the bi-metallists. The original fall in price was in America. There invention has been most active in labour-saving machines, because the price of hand labour in the Far West ranged from £80 to £94 per man. Almost every step, from the

sowing of the grain to the delivery of the flour to the consumer, is now made by machinery. It would require 160,000 reapers to harvest and bind the present crop of American wheat by the old sickle and hand-binding; now comparatively few are required. The economy of labour, both in production and transportation, has become so great, that Atkinson assures us the labour of four men for a year will grow, grind, mill, and transport 1,400 miles to the seaboard as much flour as will feed one thousand men for a whole year. These economies in production and transport of American wheat coming into competition with our home produce have struck down the wages of agricultural labourers in England. There has been no important introduction of machinery in the production of East Indian wheat, and yet the price of that has fallen. Is the cause of its low price chiefly due to appreciation of gold? There was little movement in Indian wheat till 1873, when the Suez Canal was opened to traffic. Up to that time there had been an export duty of 7 per cent. on Indian wheat, and this was removed. In 1881 Indian wheat was still 42s. per quarter, but in 1886 it fell to 31s. 6d. During this interval the cost of sea transport fell 6s. 6d. per quarter, that of railway transport 2s., while each gunny bag cost 6d. less. Thus 9s. out of the fall of 10s 6d. is accounted for without the appreciation of gold, and perhaps the active competition of America and Russia in recent years had a good deal to do with the remaining 1s. 6d. Exchanges in India are made by commodities as in all other countries. One pound sterling may get 45 per cent. more wheat from that country now than it could in 1873, but the merchant must send 45 per cent. more commodities to get it, so that the exchanging value is the same in both years.

The illustrations which I have given show that since 1873 there have been causes far more potent than variation in the price of gold to account for the fall in prices of staple commodities. Had that fall been mainly due to scarcity of

gold and the consequent appreciation of its purchasing power, one single cause such as that must have had effects all-pervading, practically synchronous, and as constant as the law of gravitation. The scarcity of gold, like the scarcity of capital which it represents, must gradually, but surely, have produced less movement, less production, and less consumption of commodities. This has not occurred, because, though prices have been low from 1873 to 1888, there has been throughout the whole period greater movement, greater production, and greater consumption of commodities. The volume of commerce has not lessened. All these facts are incomprehensible if we try to explain the fall of prices solely by the appreciation of gold. If, however, that fall has been the consequence of increased activity of inventiveness, resulting in enlarged capacity and increased economy of production, and in the cheap facilities of transport by sea and land, no fixed ratio between gold and silver can raise prices of commodities to their old standard. Low prices are not necessarily an evil. They have been compassed through high wages paid to men for superintending machinery instead of through low wages formerly paid for hand labour. The people as a whole have benefited by low prices, though profits have contracted. Still, the welfare of the many is more important than the wealth of the few.

For thirty years before 1873 machinery was steadily improving, and railways and telegraphs were gradually changing the old methods of distribution, but, on the whole, prices rose. Why did they fall so rapidly in the fifteen years after 1873? This is a fair argument on the side of the bi-metallists, because in this period there were great changes in the relative values of gold and silver. It so happened, however, that a marvellous change in commerce took place during these years. The Suez Canal was opened in 1873, and it gave a great impulse to steam navigation. Soon after this, the duplex steam-engine introduced great economy of fuel, and steamships drove two million tonnage of sailing vessels out of

their old routes, for instead of having their chief space occupied with coal, they could now devote it to cargo. The cost of ocean transit became amazingly reduced, so that local and even national markets became of less importance, and soon there was but one world-market for the chief commodities. The importance of the telegraph as a great commercial agent became more fully recognised, and thoroughly changed the old methods of commerce. This stimulated the improvements in production, which I have described in the case of the staple commodities which I selected to show what had been effected in the last fifteen years.

Let us now come to the changes in the values of gold and silver during the same period. I admit that I cannot give an equally satisfactory reason for the fall of the price of silver, and on this account I do not dogmatise and deny that there has been appreciation of gold, though I have shown that it has had little effect on the price of staple commodities which have had far more potent causes for their fall in price. It would have been natural to expect that these would have cheapened silver also. As a fact, however, there have been no striking inventions since 1873 to lessen the cost of the production of silver, either in labour-saving appliances for its extraction, or in the processes of desilvering lead. Such improvements as have been made are no doubt represented in the lower prices but are insufficient to explain it. In recent years there has been increased production of silver and a lessened output of gold, but both facts stand in such slight relation to the mass of the metals in use, that neither the depreciation of silver nor the appreciation of gold can be explained in this way. There has only been $\frac{1}{4}$ per cent. less average production of gold during the last fifteen years. Gold, in relation to silver, increases most in production over a long term of years. If we take three hundred and fifty years preceding 1850, and the thirty-five years after that date, the latter short period

shows an increase of 134 per cent. increased production of gold and only 38½ per cent. increased production of silver. It is true that for a few years there has been an annual decline in the production of gold. But with the recent activity in gold mining, this small loss is likely to be made up. The new gold fields in South Africa, New Zealand, and Australia are opening up new sources of supply. It is difficult, then, to connect the fall in the price of silver with the small appreciation of gold due to the lessened production of gold in the last few years. There has undoubtedly been some potent cause connected with silver itself which has caused its fall in price, for neither excessive production of silver nor excessive scarcity of gold give adequate explanations. I have no doubt that the Commission is right in attaching much importance to the fact that Germany and France and other countries of the Latin Union reduced the value of silver by adopting a gold standard. Germany forced a large quantity of silver on the market, and the Latin Union, when it ceased the free coinage of silver, did so also. And so it has come about, from these and other causes, that the ratio of silver to gold, instead of being 15½ to 1, is now 22 to 1. England has felt this change keenly, because, on account of her Free Trade policy, she is the chief mart for the produce of silver-using countries. It must be borne in mind that the depreciation of silver has not yet been felt in these countries, so it is not world-wide, because, if it were, the prices of commodities and the rate of wages would have risen in them, and there is no evidence to show that they have. London, as the great commercial exchange, has the chief dealings with silver-using countries. It is a huge spout, into which most of the silver flows for the settlement of the balance of trade. In recent years the natural flow of silver into this huge London spout has been disturbed by forced sales of silver, having no natural connection

with ordinary commercial dealings, and varied the usual course of exchange. The sale of silver coin by Germany; the stoppage of silver coinage by the Latin Union, were in themselves serious causes of disturbance. Then the issuing end of the London spout got continually blocked by bills of the India Council. All of these causes have acted by forcing the sale of silver at a more rapid rate than the silver-using countries could absorb it, and the silver market has been kept in a state of panic. I do not say that this is the only cause of the fall, but I believe it to be the chief cause, and if it be, the effects will only be temporary.

I know that high authorities like Mr. Giffen expect a continued and permanent fall in the price of silver, and ultimately this is likely enough. But there are counteracting causes which may retard the fall for a considerable time, and may even produce a substantial rise in the gold price of silver. The silver-using countries are opening themselves to the telegraph, to railways, and even to the use of machinery in manufactures. India is showing a remarkable development in cotton manufactures. Mexico and other silver-using countries in South America are being opened up by railways to increased trade. An industrial revolution will take place when China breaks down her Chinese wall of exclusiveness; when Russia opens Central Asia and completes the Trans-Siberian Railway; when the Euphrates is paralleled by a railway; and when Africa fails to resist advancing civilisation. None of these events are impossible, and some are in prospect of realisation. New vistas of commerce are opening in silver-using countries, and increased demand will support the price of the metal. No doubt in time, as these nations become rich, they will demand a gold standard, just as Germany, and the Latin Union, Holland, Scandinavia, and the United States have done, and then the price of silver will fall—but that is an influence of the distant future. Whether silver falls or rises in price in the future is only interesting as showing

that a legal ratio of gold to silver cannot prevent a market ratio existing side by side with it.

After my remarks you will see that I cannot even contemplate the possibility of a great commercial country like England tampering with a gold standard, or joining any international conference to consider whether an arbitrary ratio should be established between the two money metals. It was no duty of the State to interfere when prices were rising, and it cannot be its duty now when prices are falling. We are invited to enter into a conference, as the great creditor nation of the world, with other nations who are our debtors, and would gladly pay gold loans in cheap silver We now possess the best currency in the world, and work with ease our gigantic commerce by a gold implement admirably suited to perform money work. The bi-metallists desire that both gold and silver in a fixed ratio should be legal tenders. In other words, they wish a two-fold implement by attaching to gold a bulky and inferior metal which is suited to and used by half-civilised States, and is abandoned by nations when their trade increases. The exchanges of England are regulated by a fine balance-wheel made of gold. If we are to increase its bulk and weight by fusing it with sixteen or twenty parts of silver, is it not likely that we may derange the whole working of the very delicate and complex machine by which our commerce is moved? It does not follow because a gold balance-wheel is best for England, that a silver one should not be more adapted for countries with less civilisation and less commerce. A process of natural selection determines the use of metal money. It is by natural selection, and not by statute law, that money does its work in settling international balances. Gold and silver as commodities are subject to the cost of production and to the laws of supply and demand. These laws are all-powerful, and no statute law of one nation, or of ten combined nations, can prevail against them.

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THE INOSCULATION OF THE ARTS AND SCIENCES.

Address, as President of the Midland Institute, delivered at the Town Hall, Birmingham, on the 29th September, 1870.

I do not remember that I ever began an address by a confession of inability; for a man has no right to lecture to an audience unless he be capable, and ought to sink his personality in the subject matter before him. When I began to reflect how I ought to address an assemblage of Birmingham men and women with any fitness to the occasion for which we are assembled, I frankly confess that I regretted having accepted the high office of President which you bestowed upon me. I knew how much I had learned in past times by visiting your manufactories, and how much remains for me to learn from the triumphs of industry in a town where a Watt and a Boulton, a Priestley and a Murdoch, an Elkington and a Chance, a Muntz, an Osler, a Hardman, and a Winfield have laboured, so it seemed to me a mockery that my small knowledge of science should be brought into comparison with your great industrial achievements. I became the more discouraged when I recollected the character and the ability of the man who occupied the chair at your last meeting. On this subject, at least, our sympathies are in common, for your esteem and admiration for our late president are not greater than mine. Charles Dickens was a man of tender heart, who mourned for the sorrows, the injustices, and ills of mankind. He was a man of strong heart, too, and loved

to crush the injustices and tear out the ills from society in a righteous indignation. Hence he was an active social reformer, and produced, by his writings, many more effective reforms than professed politicians. There is scarcely one of his books in which he did not aim to eradicate or amend some evil under which society was suffering. The high administrators and the lazy clerks of the Circumlocution Office, the maladministrators of the Poor Law, the pompous pleaders in Courts of Law, the dawdlers in the Court of Chancery, the upholders of all systems of beadledom, the minister of religion when he was blatant and hypocritical, the professor of philanthropy when he traded on the woes of mankind, the sinecurist like the deputy chaff-wax of the patent office, the idler and the criminal who preyed upon the earnings of society—all came under his lash, until they reformed their ways and served society with honesty and efficiency. Charles Dickens was not a mere novelist. A great man, of noble sympathies and beliefs, has departed from us—one who was of the people, and worked for the people—for their profit and advantage, as well as for their entertainment and recreation—and who tried to unite all classes of society, because his own breadth covered them all. One of his last public appearances was at our Institute, and our period for mourning has not yet passed away.

All these mixed feelings confirmed me in my distrust that I had not done wisely in acting as your President. Gradually I separated myself and my shortcomings from the subject matter of your invitation, and became emboldened to address you on the intimate union between science and labour. Their interdependence is far from being simple. It is not science which creates labour, or the industries flowing from it. On the contrary, science is the progeny of the industrial arts on the one side, and on the other, of the experiences and perceptions which gradually attach themselves to these arts. So that the evolution of science from

the arts is the first circumstance of human progress, which, however, quickly receives development and impulse from the science thus evolved. Industrial labour, then, is one of the parents, and science is the child ; but, as often happens in the world, the son becomes richer than the father, and raises his position. It may not be the waste of an hour if we consider these relations more closely. Had I not been frightened with the length of the word, I would have entitled my discourse the inosculation of the arts and sciences. In one sense that means their embrace ; but in another it signifies junction with open mouths, as when two arteries join and mutually pour their contents into each other. Well, this word has found a practical expression in the minds of the Birmingham people when they founded this Institute ; and though it is long and pedantic, I will take it after all. The industrial arts spring clearly out of the necessities of man. Man is peculiarly helpless as regards his own personal and physical belongings. With an intellect which, when developed, approaches that of an angel, he has a naked, unprotected body, like that of an earthworm. Covered neither with chitine like the lobster, nor thick hide, nor with fur or feathers, he looks as helpless at his birth as the unfledged gosling ; but, unlike it, never gets a better protection from wind or weather as he grows older. Nor has he any natural tools with which he can labour. The earthworm can mine and tunnel so as to seek protection under ground ; but even this is denied to man. Every lower animal has within itself admirable tools for work. The tailor-bird can sew ; the fishing-frog can throw out line and bait ; the beaver can build bridges ; the silk-worm can spin ; the spider can weave ; the bees can manufacture sugar ; the ants can construct storehouses for their corn—all of them self-provided with admirable tools for the purpose, existing within themselves, and capable of being renewed by themselves when wasted by work. Man has

neither in hands nor feet tools sufficient for his protection or sustenance.

We know of no race of savages so absolutely wild as to possess no arts. One of the rudest races of savages, the Mincopies of the Andaman Islands, robe themselves by plastering yellow clay over their bodies; but even they have arts, for their canoes are large and fitted for heavy seas; their fishing implements and arrows, and their shell chips for shaving, are effective. Such degraded tribes as the Diggers of the American continent, or the Bosjesmans of Africa, have primitive tools and primitive arts, which grow slowly only because their surroundings have stunted the development of intellectual observation and application. These are the faculties which enable man to take a position so much higher than that of all the animals around him, notwithstanding their natural physical advantages. Man has sometimes been described as a fire-making animal, because none other than he has learned how to use it. Fire occurs naturally under various circumstances on the earth, so that it was quite unnecessary for the ancients to invent the fable of Prometheus, who had to climb for it to heaven, and bring it back in a narthex staff, or stem of the giant fennel, which has a tinder that would keep it alight. Fire exists in volcanoes; it is said to occur in tropical forests by the friction of dry branches during a storm; it comes during the fermentation of litter cut for cattle, and in various other ways. It requires the intellect of a man to keep fire alive, and use it for industrial purposes. Not even a monkey, though possessed of strong imitative faculties, is able to continue a fire for the mere purpose of warmth. There must at one time have been a race of fireless savages, though there is no distinct evidence of them in the voyages of travellers. Even Maghalhaen's alleged discovery of fireless savages in the Ladrones, in 1521, was an invention of a Jesuit father a hundred and eighty years afterwards. In

fact, fire is the essential condition for industrial development, and without it man would be a miserably helpless creature. It is his first substitute for want of fur and feathers as a protection against the inclemency of the weather. It is the origin of all his arts. He throws stones into the fire, and then casts them, when heated, into water, and thus boils his food. Soon he finds out that the water will boil in vessels placed upon the fire; but the vessels, being made of wood, burn, so he plasters them over with clay; the clay is baked by the heat, and he thus discovers pottery. Thus, step by step arise the arts—so slowly, indeed, that an acute writer like Archbishop Whateley believed that no savage tribe improved the arts, unless by introduction from another tribe of higher civilisation and culture. This is certainly a mistake. The growth of arts is indeed very slow; but few savage tribes lose a step in progress when it has been made. The stone age was succeeded by the metal age. In the progress of metallurgy it was comparatively easy to use silver, gold, and copper, which occur native, ready to hand for use; and a far greater achievement to smelt a metal from its ores. The extraction from an earth involves an immense amount of experience already gained. It does not suffice that the material should be common around you. Clay, for instance, is found in every part of the world, and contains a large quantity of a useful metal. Yet it is less than twenty years since that we succeeded in extracting aluminum from clay, so as to use it for industrial purposes. So also the ancients knew how to make brass by throwing the ore calamine into melted copper, but the extraction of zinc from the ore is a modern invention. The true metallurgic art of extracting metals from their ores came later among the arts invented by man. When the natives of Tahiti got a present of iron nails from Captain Cook, they very prudently sowed them in the ground in order to raise a crop for the next season. The Tongans were so impressed

with the qualities of axes and chisels that it was natural for them to think that, after they were worn out by use on the earth, their souls flew away to do service to the gods. No doubt it was a more intimate acquaintance with the knowledge of fire that developed metallurgy and other arts. We see that this is so by the classical fables of Vulcan. The burning of a forest on Mount Ida is said to have led to the discovery of iron. The cooking of food in a pot set on the ashes of the kali plant, at the mouth of the river Belos, is given as the origin of glass, though Mr. Chance would tell you that this pretty story must be nonsense, because the heat of a common fire does not incorporate sand with alkali.

I cite these stories only to express disbelief in them on another ground. No mere isolated chance observations of this kind ever produce an art or a science. Livingstone tells us that African savages are familiar with electric sparks coming from their fur karosses; but he also remarks—"Nothing came of it, however, for they viewed the light as with the eyes of an ox. The human mind has remained here as stagnant to the present day as it once did in England. No science has been developed, few questions even ever discussed, except those which have an interest in connection with the wants of the stomach." The observation is a just one. No science or art is developed in uncultured minds, or even in cultured ones, except as the result of very long experience and observation. Nakedness and want of tools form the stimulant to man's industry, and the arts grow slowly, and at first almost imperceptibly, from his necessities. The experience which he thus acquires becomes an inheritance of common knowledge.

Science is the evolution of that knowledge, and the mode of it is worthy of your consideration. Accumulated facts are necessary for science, but do not create it, for that arises only when man's reason acquires dominion over his senses, and teaches him to verify the impressions conveyed by them. In

savage life science is not developed, because the gratification of the senses, and subordination of everything to them, are incompatible with the evolution of science from any number of facts. Even in civilised life it is long before men learn how to subdue their senses to their reason. If you doubt it, look to the lamentable hold which spirit-rapping and table-turning got upon our communities. The believers in such phenomena tell you that they saw them with their own eyes, or heard them with their ears. So they did; but they do not understand that to see rightly, and to hear with accuracy, are about the last things a man learns. When an experimental philosopher thinks that he has made a discovery, he does not rely even on his trained faculties of observation, but spends months, sometimes years, in testing and looking at his discovery in every possible light before he announces it to the world. Yet an untrained observer, if he see a table turn round, or listen to a physical rap on a floor or ceiling, believes that he is justified in ascribing them to some odylic or spiritual influence. A nation is observant or unobservant, according to the necessities of its existence. Thus an American Indian, or an Australian native, would follow a trail over the prairies when we would be helpless. One of my friends, now resident in Edinburgh, was occupied, as a magistrate in Australia, in searching for a missing man, and was aided by natives. One of them took up an ant, and after examining it, declared it was carrying a piece of white man's flesh. Taking that as their cue, they followed other ants going on a contrary course, and came upon the body of the murdered man. Take any single subject in science, and you will find how slowly correct observation accumulates round it. A savage finds that a particular animal is fitted to serve him as food, and he kills it. Sooner or later conceptions of a Superior Being arise in his mind, and he tries to propitiate the gods by sacrificing the animals which are so valuable to him. The priests become

imperceptibly acquainted with their internal structure. After a time the priests observe that animals are weak or vigorous, and their intestines more or less healthy, according to the pastures on which they feed, so they select the sites of towns after sacrifices and inspections of the animals of the district. Thus medicine and public hygiene arose by accumulated experience, but not through science. When Alexander the Great established a department for dissection in his noble museum at Alexandria, he founded the science of anatomy, because he brought the experience of the past and the thinking materials of his day into close and active relations. You will see, then, that science does not depend upon facts alone, but upon the increase of mental conceptions which can be brought to bear upon them. These conceptions increase as slowly as the common knowledge derived from experience. They both descend by inheritance from one generation to another, until science, in its progress, becomes a prevision of new knowledge by light reflected from the accumulated common knowledge of the past.

Let me cite water as an illustration. It comes under your observation every day, and was as familiar to the ancients as to you. You look at it, taste it, use it ; and yet how slowly our knowledge of water has grown, and how much we have yet to learn. In fact, you can only see a thing and understand its properties to the extent that your inheritance of mental conceptions empowers you to do so, or according as your faculties, if trained beyond those of your fellows, enable you to march a short step further than they can go. Thales, who lived 640 years before Christ, was such a man, and boldly told us all about water. He had been in Egypt, and had seen with his own eyes crops growing from the fertilising waters of the Nile, so he knew that plants must be made of water. He had seen the exhausted sun dip below the western wave, and rise in the morning mightily refreshed with his huge drink, so he could

affirm that the sun also was made of water. He had seen it during the day send down its scorching rays and dry up lakes and pools, which went back to the sun in the reflected beams; so could any further proof be required that the sun needed water for its sustenance? Well, this became the foundation of the philosophy of the Ionian school; and, though Thales had not learned to bring his senses entirely under the dominion of reason, he gave a great impulse to the study of natural phenomena. It required two thousand five hundred years more to look at water and study its nature before it was found out that it is a compound body, consisting of two gases, oxygen and hydrogen. All this time our knowledge of this familiar body was slowly accumulating, and we were acquiring a continually-increasing inheritance of mental conceptions which enabled us to understand its properties. From the beginning of the world ice, water, and steam were known; but it was only my third predecessor in the chair of chemistry in the University of Edinburgh who showed how they were related to each other by containing different quantities of latent heat. Then we began to see how important this is in the economy of the universe. The sun of summer melts our snows, and stores up a vast quantity of heat in the water. Winter comes, and during freezing the water emits this heat again. So that the rigours of winter are tempered, and the scorching heats of summer are lessened, by this beneficent provision. Then we begin to understand how the sun acts like a great pumping engine, converting water into steam in hot districts of the tropics, and carrying it by the return trade winds to more temperate lands, which are not only watered but heated by the rays of the sun, thus transported to us from regions which might otherwise have had their oceans "boiling under the intolerable fervour of the heavens," as the wise men of Spain told Columbus would be the state of the seas through which he must pass to reach America. It was

the study of the latent heat of water which led Watt, first in Glasgow, and then in Birmingham, to his great improvements in the steam engine. In this illustration of water the argument of my address is fully borne out, that experience is the foundation of science, which in return gives a rapid development of that experience as soon as cultured reason governs the unaided senses.

One more illustration will suffice. Our acquaintance with coal tar is old and familiar. It was formerly supposed to be useful for crude purposes, and was frequently employed. Bishop Berkeley thought it contained wonderful healing properties, and used it as a sort of universal medicine, and recently various anti-periodic medicines have been prepared from it. No one, until recent years, suspected that it was a storehouse of the most beautiful dyes—of mauve, magenta, of alizarin, the colouring matter of madder, and even of indigo. No one dreamt that out of it could be extracted the materials for preparing artificial perfumes, such as the artificial oil of bitter almonds. A few years ago even chemists would have laughed if a manufacturer bought coal tar in order to prepare from it a rival to sugar, exceeding its sweetness by three hundred times. Thus gradually arises our acquaintance with familiar objects—so slowly indeed that there is no common object around us in regard to which we have anything like a complete knowledge.

You will also observe that, in the progress of time, common knowledge passes into scientific knowledge. The first is knowledge acquired by the senses; the second is an extension of these perceptions by cultured reason. As a necessity for its growth in a nation, a higher degree of civilisation and prosperity is necessary than is involved in a mere struggle for existence. A class of men who devote themselves to the increase of mental perceptions imply a superfluity of riches beyond the immediate necessities of the community. A learned class, or even an educated class of

manufacturers and artisans, involve the condition and willingness of a certain amount of wealth being diverted from material necessities to mental development. And so we find that just as early nations became rich and prosperous, so did philosophy arise among them, and it declined with the decadence of material prosperity. In those splendid days of Greece, when Plato, Aristotle, and Zeno were the representatives of great schools of thought, which still exercise their influence on mankind, Greece was a great manufacturing and mercantile community; Corinth was the seat of the manufacture of hardware; Athens that of jewellery, shipbuilding, and pottery. The rich men of Greece and all its free citizens were actively engaged in trade and commerce. The learned class were the sons of those citizens, and were in possession of their accumulated experience derived through industry and foreign relations. Thales was an oil merchant; Aristotle inherited wealth from his father, who was a physician, but, spending it, is believed to have supported himself as a druggist till Philip appointed him tutor to Alexander. Plato's wealth was largely derived from commerce, and his master, Socrates, is said to have been a sculptor. Zeno, too, was a travelling merchant. Archimedes is perhaps an exception, for he is said to have been closely related to a prince; but if so, he is the only princely discoverer of science on record. These intellectual heroes of antiquity sprang from the people, whose experience and knowledge became their inheritance. It was by applying their cultured reasons to this accumulated stock of experience that they advanced philosophy among mankind. Even now the same thing is requisite. You see it illustrated in a great thinker like Spinosa, who refused rank, pensions, legacies, wealth, in order that he might keep himself among the people, and inspire their intellectual vigour; so he preferred to support himself by grinding object-glasses for microscopes and telescopes. How seldom is it, though leisure and wealth

exist among the aristocracy of a country, that science is promoted by them! Boyle, who was once described as "the father of modern chemistry and brother of the Earl of Cork," and Cavendish, are exceptions; but the giants of our period are born of the citizens as of old. It is not superfluity of riches in the individual that draws out a learned or inventive class; it is rather superfluity of riches in a nation actively engaged in industrial occupations. Poverty in the individual is the stimulant to exertion, while wealth is not unfrequently the narcotic producing intellectual torpor. No doubt there are men in all classes who do not succumb to the benumbing influences of wealth. Formerly the aristocracy furnished a large proportion of our statesmen, though latterly they also have come from the productive classes, as instanced in the Cobdens, Brights, and Gladstones. Still there are eminent statesmen from the upper classes, showing that hereditary talents among them are of a high order. Why is it, then, that they advance science so little? Precisely because, like the schoolmen of the middle ages, their education separates them from the fund of common knowledge accumulating among an industrious people.

Long after Greece and Rome had flourished and faded, most part of Europe was in a state of barbarism. As it grew in civilisation, the learned classes grasped at the philosophy of the past, for there was nothing among themselves comparable to it. They were truly dark ages, for they had no light of their own; and the borrowed light of Greece and Rome, though it illumined dimly the studies of the learned, yet was obscured from the people. Even the languages of these nations of antiquity were used by the learned class to express their ideas, and they thus chained themselves to the past ages, and became separated from the experience and growth of conceptions among the people around them. No philosophy or science could grow under such conditions.

Hence the philosophy of Aristotle sufficed for fifteen centuries after his death ; nay, now, twenty-two centuries after, it is still taught at our universities. So late as the year 1771, the University of Salamanca recorded, by solemn decision, that they could not teach the discoveries of Newton because they were discordant with the system of Aristotle. Nothing so stunts the growth of intellect as a credulous dependence on past authority and its separation from active industry. You see this evil intensified in China, where there is a learned class approaching in theory to all that we could wish. There, the only source of power is intellect. By that she has solved the great problem of keeping a population equal to a third of the human race on a surface not so large as Europe, and with climatic variations not far differing from it. To this intellectual organisation is no doubt due her national longevity; though she is losing her vitality. Her agriculture is still marvellously advanced, but her other industries are failing. The reason is that just as Europe so long worshipped the philosophies of Plato and Aristotle, so China still worships the philosophy of Confucius and Mencius, and bases her official examinations on the writings of these philosophers. So China chains herself to the past, and allows the present to float past her. The schoolmen would have done this evil for Europe, had it not been that the industrial classes, from whom they had separated themselves by the adoption of extinct languages, began to advance beyond them in perceptions and experience. The name of "journeymen," still existing among workmen, shows how artisans in former times, by travelling from place to place, gathered up experience and increased their perceptions. And what these journeyings did for individuals, the great geographical discoveries did for nations You see that well illustrated in the Venetian Republic. When the inhabitants of the peninsula were driven into the lagoons and marshes of Adria in the fifth century, few could have told their future greatness.

Yet they became the carriers of the world, while their energies were strengthened by the inroads and attacks of the Saracens. Their merchants bought back knowledge and experience as well as wealth ; and Marco Polo and Marino Sanudo explored distant lands where Venetian commerce had not yet reached. Following these discoveries came the boundless thirst for knowledge that characterised the Venetians ; and Venice has left its mark on time less by its commerce than by its intellectual activity.

By the end of the fifteenth century most of our present industries, especially those for which Birmingham is famous, were well established. Guns, watches, wire-drawing machines, telescopes, table forks, knitting-needles, horse-shoes, glass, and mirrors made from it, had been already invented. About the middle of that century printing was introduced, and learning, hitherto confined to the few, could be scattered among the many. The pulpit lost its power, and the press gained it. In the sixteenth century, newspapers began to appear in Europe—first in Venice, then in France—though they did not fully establish themselves in England till the period of the Civil Wars. They were published in the vernacular, and the learned class began to feel themselves outside the world with their intercommunications in Latin and Greek. Yet none other would have enabled Europe in her barbarism to have profited by the intellectual civilisation of antiquity. At this time the accumulated experience derived from advancing industries, and the mental perceptions flowing out of them, were greater than in the best days of Greece and Rome. Yet it was not till the close of the eighteenth century that the vernacular was generally used in our schools. This knocked down the great barrier to progress, for the learned class and the industrial class became again united, and could travel on the same road, as they had done when Greece and Rome accumulated their intellectual treasures for posterity. To this day the upper classes do not

realise this fact, and they continue to cut off one-third of the lives of their children by an exclusive devotion to classical literature; and when the youth of the upper classes awake to the realities of life, they find themselves unprepared to profit by them. Like Rip Van Winkle, they wake from their sleep only to find that they are twenty centuries behind their generation, and can do it little good. They rarely advance the science or philosophy of the present; though they make good statesmen, because they have had noble studies of human mind and human actions in the glorious records of antiquity; for these have the same springs now as when Greece had its greatest prosperity and intellectual vigour.

So far as regards politics, ethics, sculpture, painting, and architecture, the world has advanced little beyond, if it has reached the position attained by Greece and Rome. These, though they grace, do not now form the foundation of a nation's prosperity. That is formed from the applications of science to industry. It is through the industrial class that new experiences and perceptions accumulate; it is through them that a superfluity of wealth is directed to the support of a separate learned class; and it is from them mainly that this learned class takes its origin.

Hitherto we have been looking at the evolution of science from the arts. Now let us see how the latter receive their great impulse from the former. In early ages the raw material at hand led to its industrial application; and, in later ages, it impressed the character of industries upon the country possessing it. Thus the mound builders of the Mississippi became coppersmiths, because native copper was found near them, though the ignorant savages thought it a mere variety of stone, and chipped and hammered it into tools without even knowing how to forge it hot. Those who did not dwell near native metals became workers in stone, in flint, in bone, horn, or shell, according as the one

or other was nearest to their hands. As civilisation progressed and commerce became established, the mere possession of raw materials was not the only condition of industry. Adventurous nations emerged out of the surrounding barbarism. The Phœnicians, at a time when their neighbours the Thracians, scalped their enemies and tattooed their own bodies, navigated the Mediterranean, and, following the Tyrians, made their way across the ocean to Great Britain, where they found its natives dressed in skins, or with bodies daubed over with ochre or woad. They brought back tin, with other minerals, and established metallurgic industries, which are still carried on by all nations. When any tribe or nation can take from another the raw material, which the last either does not use or uses with less intelligence, the first nation must be under the guidance of science. The science may be undeveloped, dealing with qualities only and not with quantities, but science it must be; for it is impressing upon the material the conceptions derived from cultured intelligence, and making these of a higher relative value than the mere local possession of the material itself. This is the great element of industrial competition in the world at the present time. Take the case of Great Britain in modern days. We have coal, ironstone, and lime, in large quantities, and in fortunate proximity. We have copper, and tin, and zinc, in smaller proportion. As intelligence arose in this country, and initiatory science became evolved from industrial pursuits, the inhabitants no longer sold their mineral wealth to distant nations, but manufactured it for themselves. As long as the growing intelligence of our inhabitants equalled or exceeded that possessed by any neighbouring nation, our prosperity was secured; because, in addition to the science of the time, the raw material of industry was in our possession, and competition with us was an impossibility. And so is it with all nations. The moment that any nation allows the intellectual element of production to fall below

that of its neighbours, the local advantage no longer suffices for superiority. When commerce and science open up paths of rapid intercommunication throughout the world, the cost of transit of raw material is diminished, and the intellectual superiority of another nation far more than balances the possession of raw material. Roads, railways, ships, and steamboats, arising in the march of science, can spread raw material everywhere, and enable nations to test their relative intellectual powers applied to it. Intellect now largely exceeds the value of the raw material as a factor in production. Cotton is grown in America, crosses the broad Atlantic as a bulky and expensive freight, is seized hold of by our mechanical science and manufacturing enterprise, crosses the Atlantic again as calico, pays a heavy import duty, and yet undersells the products of the mills at Lowell. When the great American people, through their rising colleges, and by a better understanding of the effects of restrictive tariffs, apply their intellectual powers in this direction, such relative superiority of manufacturing science will be impossible in the presence of the raw material at the doors of their mills. More strange still to see Switzerland, with no seaboard and no coal, bringing cotton from America, transporting it through the defiles of the mountains, then back again over land and sea, in the form of high priced cotton goods, and underselling America in her own markets, What enables such a country to do this? It is not cheapness of labour; it is intellectual or scientific superiority in relation to the manufacture which competes successfully against local advantages. Take another instance. Sweden has excellent iron, and sends it to Birmingham, where you convert it into tools, axes, chisels, and hoes. You send these to America, though good iron ore exists in that country. Well, some day the Americans find that by giving a different edge and temper to their axes, or a different form to their hoes, they can do their own work better so they send to

Sweden for the iron, and fashion it into their peculiar forms and Birmingham does not send so many axes and hoes as formerly; while America actually sends some to this country, to see whether we like their new forms better than our own. You see that, in an advanced period of manufacture, the mere possession of the raw material confers but a small advantage on the country, and that the changes which are continually taking place are not regulated by it. The intellect, which has such a predominant value, receives its expression, at least to a large extent, in incessant efforts to convert the brute labour of a man into an intellectual superintendence of labour performed by a machine. This may be illustrated by any branch of industry taken at random. I see opposite my study window, as I write, a house in course of erection, and the labour of the builder will serve my purpose as well as any other. An Irish hodman is carrying a quantity of bricks up a ladder, in order to supply material to the builder. The sight is familiar to us still, though not so much so as it was a few years since, because a change is passing over this form of labour. Let us study the reasons for the change. The Irish hodman is a human machine, unskilfully and expensively put into operation. He felt that himself, in his fine, confused way, when he wrote to his friend in Ireland, "Dear Pat, come over here and earn your money: there is nothing for you to do but to carry the bricks up a ladder, for there is a man at the top who takes them from you and does all the work!" The man at the top is a skilled workman, more nearly fulfilling his human functions, for he is using intellect in his work. The hodman is a worker also, but only a user of his own brute force in a very unintelligent way. Every time that he ascends the ladder with his load of bricks he is carrying up his own weight in addition to that of the bricks; his force is thus wastefully expended. After many years his employer perceives this, and substitutes for human labour,

first that of a horse, then that of a steam engine. Now, when you pass a house in course of erection, you will see a horse trotting over a prescribed course. It is pulling up a whole barrowful of bricks by a rope and pulley. The horse, tended by one man, is doing the work of seven or eight hodmen, and with much economy of money, inasmuch as the cost of the hay and oats, from which its power is derived, scarcely exceeds that of the beef, potatoes, and beer of a single hodman; while increased economy of labour is also attained, because the weight represented by the bodies of seven hodmen is not drawn up along with the bricks. Food, burned within the bodies of the men and the horse, is in both cases the source of power. Again, in large houses the horse disappears, and a small steam engine draws up the bricks. Economy is again achieved, for the coal, which is the food of the engine, is less costly than the hay and oats required for evolution of force in the horse. A single man, using trained intelligence in the guidance of the engine, is now through it doing the work of several horses or many men. Let us analyse the changes which pass over the forms of labour illustrated in this particular case. The first tendency is to substitute the brute force of a man by an intellectual superintendence of a cheaper form of force, either animal or physical, the aim being to obtain economy of production, either through economy of time, or by the substitution of cheaper forms of force for human labour. In fact, economy of time generally follows the economical substitute of force. Savages have an utter disregard of time in the performance of labour. They will expend a month in sharpening a single arrow. Some of the rock crystal cylinders, worn by chiefs as ornaments, are stated to take two men's lives to perforate. The Kamchadals of North-Eastern Asia take three years to hollow out a canoe, and one year to scoop out the trough in which they cook food. As soon as a savage tribe employ fire, instead of imple-

ments made of stone or bone, to hollow out their canoes, they are using a natural power to economise time and brute human force, and are on the high road to civilisation. In human progress it is always so, for it is a natural law that the sweat of the brow should be lessened by the conception of the brain. The economy produced by the substitution of cheaper for dearer forms of force is remarkable in all cases where it is applied. The Prussians saw this very well when they tried to make England declare coal contraband of war in the French campaign, for it is representative of so many men added to the enemy; three or four pounds of coal, even in the wasteful way in which it is used, are more than equal to a man's force. The importance of the transformation may be better understood if you view the force of coal as expressed in men's power; just as we do in speaking of an engine as having so many horse-power. If human force were alone used in this country, the sum of production must be limited by the number of inhabitants. In such a case the United Kingdom could not produce more than the products of the labour of its thirty-six millions of inhabitants of all ages. The coal excavated annually in this country represents, in actual attainable work, almost exactly the sum of the force of the whole population of the globe, viewed as adults. So that the use of a natural force, in substitution of human power, augments vastly the productive resources of our small insular kingdom, and enables it not only to supply its own wants but also to export to other countries its superfluity of production.

Such substitution of physical powers for human force arises only in the countries in which labour is free and unfettered by servile restrictions. Liberty is one of the greatest springs of human progress. If you wish to see human labour in its lowest and least productive forms, stifling progress and choking science, which can only breathe in a free atmosphere, you must look to it as exercised in a state of

slavery. Both Greece and Rome perished as nations by accumulating slaves. These represented property, and the substitution of human labour by natural forces was a menace to that property. A citizen with slaves crushes invention, lest it should interfere with their value in the market; just as our workmen, two generations ago, destroyed machinery, as being likely to affect the selling price of their labour. The great empire of Assyria perished by the number of its captive slaves. Slavery was the worm that gnawed at the root of Greece's prosperity; and she perished. It is true that Greece, unlike Rome, encouraged and honoured industry, so long as human labour could perform it, and, by associating it with cultured reason, she had 1,200 years of splendid intellectual development. Rome, on the other hand, contemned industry, and depended on the spoliation of other countries for her wealth. She drove their able-bodied inhabitants into slavery. When Paulus Emilius conquered Epirus, he is said to have killed or carried into slavery 150,000 people. Roman citizens were soldiers, or lived on the produce of slave labour, looking upon trade as vile and ignoble, only suitable for a servile class. Slaves are mere machines, and cannot invent; for machines do not invent new ones. So when Rome, which had become a huge baracoon for slaves, exhausted the wealth that had been won by rapine and conquest, she had no elements for continued prosperity. The practical aptitudes and energies of her people were immense, but they had been misdirected. Without active productive industry there can be no continued prosperity in a nation. The depressing effect of slavery is seen in all periods of history. If there could have been an exception to it, this must have been shown in the empire founded by Charlemagne. That great Emperor of the West tried to foster learning and to organise slavery at the same time. Aided by our countryman, the learned Alcuin of York, and two Scotchmen, Hepburn and Melrose, he founded universities and schools both in Italy and Germany.

He tried to lessen the evils of slavery by apprenticing the slaves to special crafts and trades, but he had not courage to destroy utterly the accursed thing. And so, even during his life, the canker worm of slavery gnawed away the props of his splendid throne, and soon after his death it crumbled to pieces. Did time not fail me, I should like to have shown how it injured this country through its colonies, even in the lifetime of many of us. You may think that all these things are of the past, and have no application to us now. You are mistaken. There is a slavery in ignorance which is seriously deterimental to a people. Liberty in thought, in expression, and in action is essential to human progress. Science can only prosper when she follows Descartes' maxim, that you are to take nothing as true on the authority of others. "*Ne recevoir jamais aucune chose pour vraie qu'on ne la connaisse evidement être telle.*" If science be not free enough and strong enough to battle against all untrue opinions, whether in religion or politics, she cannot advance; and "*la science arrêtée arrête la monde.*" If industries be hampered by selfish rules of unions, whether they be those of masters or men, by which production is retarded, and intelligence and skill discouraged, the industries must languish and die in those places deprived of a natural liberty. The masters or the labourers may ruin themselves or their children by slavish restrictions on trade, but they are powerless in restraining the advance of scientific applications to industry. It is a law of progress which neither nations, trades, nor individuals can resist—that as civilisation progresses the brute labour of the man must be lightened by the use of natural forces. The latter can often do in a few hours, under the guidance of intellect, what the unaided labour of a man could not do in a lifetime. This is how all men should work: they should use their heads as well as their hands, so as to save the labour of the hands by the well-conceived thoughts of the head. As inventions can only be made by free men, the wonderfully

rapid growth of manufactures in Great Britain is closely connected with our free laws and institutions.

The amazing changes which have taken place since 1838 are also due to our better conceptions of force, and their mutual relations and conversions. Formerly heat, light, electricity, magnetism, and chemical affinity were thought to be separate and independent existences, not even related to each other. Now we know that forces are convertible and interchangeable. This knowledge has already given great stimulus to their application, and will do so more in the future. Further, we know that the primary source of nearly all the power on the earth is the sun above us. Steam engines are worked by solar force stored up in coal, the residue of extinct plants that grew by the agency of sunbeams, which they trapped and stored up for our use. The gas in the streets is this old trapped sunlight of some millions of years since let loose to illuminate the darkness. Our waterwheels are turned by the sun, which licks up water by his heat, transports it in clouds, and lets it loose as rain on the mountains, whence, by its descent, it turns the mills and grinds the corn. Recollect that all this is effected by a mere pencil of light reaching the earth; for our globe receives only about the two-millionth part of the solar energy rayed from the sun. It is strange to see the human intellect trying to catch this idea in all countries and in all times, though it has only been patent to philosophers within the last few years. Thus, the sun is made the patron of craftsmen, as in the old Sanscrit hymn: "He steps forth the splendour of the sky, the wide-seeing, the far-aiming, the shining wanderer; surely enlivened by the sun, do men go to their tasks and do their work." You have his power typified in the mythology and solar myths of the ancients, from Sol, the Son of the Ocean, who taught men the arts of mining and metallurgy, to the great Quetzalcohuatl of the Mexicans, who was the sun typified as a warrior, and a

founder of many countries and teacher of all sciences, arts, and crafts. So important was the sun deemed as the author of all work, in the most widely-separated lands, that everywhere you find tales of how nooses and traps were set for him as he came out of the east in the early morning, in order that he might be subjugated to the use of man. In Greece nature was disguised under attractive polytheistic agencies, yet we find Anaximander giving great prominence to the action of the sun and fire, and Herakleitus actually announcing the interchangeable character of forces, though he naturally confused them with the properties of matter. In the life of George Stephenson, an anecdote is told of how, at Drayton Manor, he described, in a flash of genius, that it was the sun which drove locomotive engines, by being liberated from coal in which it had remained trapped for ages. The anecdote proceeds to tell how the late Sir Robert Peel induced Follett, the great lawyer, to act as counsel for Stephenson against the arguments of the scientific men who were there, and who opposed the startling assertion as purely fanciful. The story is quite true, for I myself was one of the party, and was employed to cram Follett with scientific arguments in support of the startling proposition, though I confess that I could not then see the beauty of the conception, which all now acknowledge as a truth. I have referred to the nature of force because I wish you to understand that in all you do, by new inventions or applications of old ones, you cannot turn natural forces, or the properties of bodies derived from their action, by a single hairbreadth out of their course. You can neither create forces nor endow anything with properties. All that you can do is to convert and combine them into utilities. If you do this with knowledge, you are saved the dismal failures of ignorance; but if you try to use powers for your own purposes without understanding them, the invariable operation of law is shown in the punishment of your presumption. This is the cause of the heavy

mortality and disease which follow in the wake of civilisation. You use a defective grindstone; it flies and kills the workman using it. A weak plate is put in a boiler, or sound plates are allowed to corrode through carelessness; the boiler bursts, and scatters desolation around. The employer of labour or the workman may have no other fault, in these accidents, except that of ignorance; but neither civil law nor natural law admits that as a palliation of its breach. Nature is wondrously bountiful to the wise, but has no bowels of compassion for the ignorant. Break but one of her laws, wilfully or ignorantly, and the punishment is swift and sure. On this account we cannot go anywhere in our great manufacturing towns, or crowded communities, "without treading on dead men's bones." Take any illustration you like in proof of this. Even with our long acquaintance with fire, the ignorance of its laws is great, and the punishment of this ignorance is also great. Surely in civilised England one would think that no human being need be burnt alive by fire, or scalded to death by boiling water. Yet in the last twenty years 56,000 people in England and Wales have perished in this horrible way. You could not parallel such a holocaust either in the sacrifices of the Druids, in the fires of Moloch, in the auto da-fés of the Inquisition, or in the Suttees of the Hindoos. And if history refuse to hear of any palliation of these human sacrifices, depend upon it the nineteenth century will be held responsible for such preventible mortality. Englishmen used to hear with horror of the deaths of Hindoos, crushed under the wheels of the car of Juggernaut; and they never rested till they put an end to the human sacrifices of that remorseless god. They think little of the far more terrible sacrifices of victims daily crushed to death by wheels and waggons in our overcrowded streets. We shudder now and then at the account of some mine explosion, when twenty or thirty human beings are killed. Yet the total results of all such explosions through-

out the United Kingdom only equal the number who actually perish in London alone by the traffic of its streets. In intelligent, well-educated, and well-ordered communities, deaths by violence should be impossible, and yet, in the last five years, 83,853 persons have perished by violence in England and Wales. The needle-guns, chassepôts, mitrailleuses, and rifled cannon which have been lately belching forth destruction between two civilised nations cannot match this wonderful feat of a period of peace. Just as in war, while twenty per cent. of its victims perish on the field or die of wounds, eighty per cent. die of diseases which follow a camp life, so in peaceful occupations, the preventible deaths by violence are small in comparison with the preventible deaths which follow as infringements of sanitary laws. They are as definite and inexorable as any law in physics. You go to the top of a precipice and topple over it, and the law of gravitation most surely pulls you down with increasing swiftness, till it dashes you to pieces on the ground. You brought yourself under the law of gravitation, and never dreamt that it would alter its action, by a hair-breadth, to save you from your folly or ignorance. So is it with sanitary laws. Swift, stern, inexorable, and invariable in their action, they punish all violations. Man was not born into the world that he might pine and die, but that he might grow in vigour, and live his allotted period. Health is the normal state of obedience to law, disease the penalty of its infringement. In consequence of this disobedience, our kingdom has 110,000 lives ruthlessly sacrificed every year, while 220,000 people are needlessly sick all the year round. And why? Because neither our rulers nor our people will become acquainted with and obey simple sanitary laws. Our systems of education are based on the refinement and embellishment of an existence which we are never taught how to preserve. Even now, out of the thirty-three million persons who die yearly in the world, one

human being dies needlessly at every breath we take. In Goethe's celebrated educational allegory, he makes all the children study the laws which bear on their well-being. The passage is a fine one—"From the bounty of the earth we are nourished. The earth affords unutterable joys; but disproportionate sorrows she also brings us. Should one of our children do himself external hurt, blameably or blamelessly; should others hurt him accidentally or purposely; should dead involuntary matter do him hurt; then let him well consider it; for such dangers will attend him all his days."

What I have said hitherto has been merely the long text of a very long sermon which, however, I do not intend to preach on the present occasion: for its application to yourselves will arise in your own minds without the necessity of listening to it. We have seen that the necessities of man gave birth to the arts, and that from them is evolved science, as soon as cultured reason begins to connect, to explain, and previse knowledge acquired by experience. Then science, in its turn, gives speedy and vigorous development to the arts, so powerfully indeed that the raw material of industries, or the manual skill applied to its conversion to utilities, becomes altogether subordinate to the intellect engaged in production.

I have addressed you to little effect if you are not convinced that human progress is under the dominion of law, beneficent in its wisdom, but so perfect that all man's attempts to twist or turn it to his own advantage result in the swift and sure punishment of his folly. Nations rise in prosperity because they are in harmony with law, and they fall because they put themselves in opposition to it. One nation of antiquity had such a marvellous industrial development, even at remote periods, that there are men who believe that its knowledge was derived, not from experience, but through direct inspiration. I allude to ancient Egypt,

whose arts of engineering and architecture, whose knowledge of hydraulics and metallurgy, of glass-blowing and pottery, of spinning and weaving, of dyeing, and, in fact, of most of the industrial arts as well as some of the sciences, were immensely superior to the nations around; for even Greece derived a large part of her knowledge from that ancient people. So great was the learning of Egypt, that when we are told of Moses being "learned in the wisdom of the Egyptians," we require no further evidence of his qualifications to be a great leader of men. When he conducted the exodus of the Children of Israel, Egypt was already hoary with age. Her great pyramid, which still remains a monument of her greatness, had existed as long as our Christian era when Jacob passed into Egypt. The fertilising power of the Nile over a region protected on the one side by a burning desert, and on the other by the Red Sea, gave her the elements of prosperity and security. But where is Egypt now? Let me answer in the quaint words of old Sir Thomas Browne: "Egypt itself is now become the land of obliviousness, and doteth. Her ancient civility is gone, and her glory hath vanished as a phantasma. Her youthful days are over, and her face hath become wrinkled and tetrick. She poreth not upon the heavens; astronomy is dead to her, and Knowledge maketh other cycles."

It is true that knowledge changeth her cycles, so let no nation glory in her strength or plume herself in the practical aptitudes of her people. Yet it would be sad to think that knowledge coming round in her cycles is unable to regenerate degenerated lands. Those who know the educational efforts which are now making in Roumania, Bulgaria, Greece, and Italy, would be loth to deny it. If a nation do not keep herself on a level with scientific discoveries, which are always making and never ending, she must be content to slip back while the world is advancing. A nation ought to resemble the globe on which we live, by being

always in motion. That motion, however, is not merely of one kind, a mere turning round and round on its own axis, for ever and ever in the same way. The world, while it does turn round, moves onwards with a rapid, resistless sweep. Since I began to address you this evening, our world has moved in rotation only by a few hundred miles, but its onward motion has advanced it more than eighty thousand miles through space. It is this forward advance for which nations should strive. No fear of the progress of the world, though nations should stand still and vanish out of sight. Knowledge does not perish because nations decay. Just as an object attracted by the earth falls to it with an ever-increasing velocity, so does human progress advance with an accelerating speed towards knowledge. Pascal said truly, "The entire succession of men, through the whole course of ages, must be regarded as one man, always living and incessantly learning." This is a true expression of human progress. Nations, like the ripples on the sand, may stand for a time, or make their impress so permanent, that we find them, as we do ancient ripple marks, in a fossil state, for study in future ages; or they may be obliterated altogether by a reflux wave; yet the tide of knowledge is flowing steadily onwards, and will cover the land in its appointed time.

SCIENCE AND THE STATE.

This was the Presidential Address at the Aberdeen meeting of the British Association for the Advancement of Science in 1885.

I.—SCIENCE AND THE STATE.

I CANNOT address you in Aberdeen without recollecting that when we last met in this city our President was a great prince. The just verdict of time is that, high as was his royal rank, he has a far nobler claim to our regard as a lover of humanity in its widest sense, and especially as a lover of those arts and sciences which do so much to adorn it. On September 14, 1859, I sat on this platform and listened to the eloquent address and wise counsel of the Prince Consort. At one time a member of his household, it was my privilege to co-operate with this illustrious prince in many questions relating to the advancement of science. I naturally, therefore, turned to his presidential address to see whether I might not now continue those counsels which he then gave with all the breadth and comprehensiveness of his masterly speeches. I found, as I expected, a text for my own discourse in some pregnant remarks which he made upon the relation of Science to the State. They are as follows:—"We may be justified in hoping . . . that the Legislature and the State will more and more recognise the claims of science to their attention, so that it may no longer require the begging-box, but speak to the State like a favoured child to its parent, sure of his paternal solicitude for its welfare; that the State will recognise in science one

of its elements of strength and prosperity, to foster which the clearest dictates of self-interest demand."

This opinion, in its broadest sense, means that the relations of science to the State should be made more intimate because the advance of science is needful to the public weal.

The importance of promoting science as a duty of statecraft was well enough known to the ancients, especially to the Greeks and Arabs, but it ceased to be recognised in the dark ages, and was lost to sight during the revival of letters in the fifteenth and sixteenth centuries. Germany and France, which are now in such active competition in promoting science, have only in recent times publicly acknowledged its national importance. Even in the last century, though France had its Lavoisier and Germany its Leibnitz, their Governments did not know the value of science. When the former was condemned to death in the Reign of Terror, a petition was presented to the rulers that his life might be spared for a few weeks in order that he might complete some important experiments, but the reply was, "The Republic has no need of savants." Earlier in the century the much-praised Frederick William of Prussia shouted with a loud voice, during a graduation ceremony in the University of Frankfort, "An ounce of mother-wit is worth a ton of university wisdom." Both France and Germany are now ashamed of these utterances of their rulers, and make energetic efforts to advance science with the aid of their national resources. More remarkable is it to see a young nation like the United States reserving large tracts of its national lands for the promotion of scientific education. In some respects this young country is in advance of all European nations in joining science to its administrative offices. Its scientific publications, like the great palæontological work embodying the researches of Professor Marsh and his associates in the Geological Survey, are examples

to other Governments. The Minister of Agriculture is surrounded with a staff of botanists and chemists. The Home Secretary is aided by a special Scientific Commission to investigate the habits, migrations, and food of fishes, and the latter has at its disposal two specially-constructed steamers of large tonnage. The United States and Great Britain promote fisheries on distinct systems. In this country we are perpetually issuing expensive Commissions to visit the coasts in order to ascertain the experiences of fishermen. I have acted as Chairman of one of these Royal Commissions, and found that the fishermen, having only a knowledge of a small area, gave the most contradictory and unsatisfactory evidence. In America the questions are put to Nature, and not to fishermen. Exact and searching investigations are made into the life-history of the fishes, into the temperature of the sea in which they live and spawn, into the nature of their food, and into the habits of their natural enemies. For this purpose the Government give the co-operation of the navy, and provide the Commission with a special corps of skilled naturalists, some of whom go out with the steamships and others work in the biological laboratories at Wood's Holl, Massachusetts, or at Washington. The different universities send their best naturalists to aid in these investigations. The annual cost of the Federal Commission is about £40,000, while the separate States spend about £20,000 in local efforts. The practical results flowing from these scientific investigations have been important. The inland waters and rivers have been stocked with fish of the best and most suitable kinds. Even the great ocean which washes the coasts of the United States is beginning to be affected by the knowledge thus acquired, and a sensible result is already produced upon the most important of its fisheries. The United Kingdom largely depends upon its fisheries, but as yet our Government have scarcely realised the value of such scientific

investigations as those pursued with success by the United States. Less systematically, but with great benefit to science, our own Government has used the surveying expeditions, and sometimes has equipped special expeditions to promote natural history and solar physics. Some of the latter, like the voyage of the *Challenger*, have added largely to the store of knowledge ; while the former, though not primarily intended for scientific research, have had an indirect result of infinite value by becoming training-schools for such investigators as Edward Forbes, Darwin, Hooker, Huxley, Wyville Thomson, and others.

In the United Kingdom we are just beginning to understand the wisdom of Washington's farewell address to his countrymen, when he said: "Promote as an object of primary importance institutions for the general diffusion of knowledge. In proportion as the structure of a government gives force to public opinion, it is essential that public opinion should be enlightened." It was only in 1870 that our Parliament established a system of national primary education. Secondary education is chaotic, and remains unconnected with the State, while the higher education of the universities is only brought at distant intervals under the view of Parliament. All great countries except England have Ministers of Education, but this country has Ministers who are only the managers of primary schools. We are inferior even to smaller countries in the absence of organised State supervision of education. Greece, Portugal, Egypt, and Japan have distinct Ministers of Education, and so also among our colonies have Victoria and New Zealand. Gradually England is gathering materials for the establishment of an efficient Education Minister. The Department of Science and Art is doing excellent work in diffusing a taste for elementary science among the working classes. There are now about 78,000 persons who annually come under the influence of its science classes, while a small

number of about two hundred, many of them teachers, receive thorough instruction in science at the excellent school in South Kensington of which Professor Huxley is the Dean. I do not dwell on the work of this Government department, because my object is chiefly to point out how it is that science lags in its progress in the United Kingdom owing to the deficient interest taken in it by the middle and upper classes. The working classes are being roused from their indifference. They show this by their selection of scientific men as candidates at the next election. Among these are Professors Stuart, Roscoe, Maskelyne, and Rucker. It has its significance that such a humble representative of science as myself received invitations from working-class constituencies in more than a dozen of the leading manufacturing towns. Before long I do not doubt that a Minister of Education will be created as a nucleus round which the various educational materials may crystallise in a definite form.

II.—Science and Secondary Education.

Various Royal Commissions have made inquiries and issued recommendations in regard to our public and endowed schools. The Commissions of 1861, 1864, 1868, and 1873 have expressed the strongest disapproval of the condition of our schools, and, so far as science is concerned, their state is much the same as when the Duke of Devonshire's Commission in 1873 reported in the following words:—"Considering the increasing importance of science to the material interests of the country, we cannot but regard its almost total exclusion from the training of the upper and middle classes as little less than a national misfortune." No doubt there are exceptional cases and some brilliant examples of improvement since these words were written, but generally throughout the country teaching in science is a name rather than a reality. The Technical Commission

which reported last year can only point to three schools in Great Britain in which science is fully and adequately taught. While the Commission gives us the consolation that England is still in advance as an industrial nation, it warns us that foreign nations, which were not long ago far behind, are now making more rapid progress than this country, and will soon pass it in the race of competition unless we give increased attention to science in public education. A few of the large towns, notably Manchester, Keighley, Bradford, Huddersfield, and Birmingham, are doing so. The working classes are now receiving better instruction in science than the middle classes. The competition of actual life asserts its own conditions, for the children of the latter find increasing difficulty in obtaining employment. The cause of this lies in the fact that the schools for the middle classes have not yet adapted themselves to the needs of modern life. It is true that many of the endowed schools have been put under new schemes, but as there is no public supervision or inspection of them, we have no knowledge as to whether they have prospered or slipped back. Many corporate schools have arisen, some of them, like Clifton, Cheltenham, and Marlborough Colleges, doing excellent educational work, though as regards all of them the public have no rights and cannot enforce guarantees for efficiency. A Return just issued, on the motion of Sir John Lubbock, shows a lamentable deficiency in science teaching in a great proportion of the endowed schools. While twelve to sixteen hours per week are devoted to classics, two or three hours are considered ample for science in a large proportion of the schools In Scotland there are only six schools in the Return which give more than two hours to science weekly, while in many schools its teaching is wholly omitted. Every other part of the kingdom stands in a better position than Scotland in relation to the science of its endowed schools. The old traditions of education

stick as firmly to schools as a limpet does to a rock ; though I do the limpet an injustice, for it does make excursions to seek pastures new. Are we to give up in despair because an exclusive system of classical education has resisted the assaults of such cultivated authors as Milton, Montaigne, Cowley, and Locke? There was once an enlightened Emperor of China, Chi Hwangti, who knew that his country was kept back by its exclusive devotion to the classics of Confucius and Mencius. He invited five hundred of the teachers to bring their copies of these authors to Pekin, and after giving a great banquet in their honour, he buried alive the professors, along with their manuscripts, in a deep pit. Confucius and Mencius still reign supreme. I advocate milder measures, and depend for their adoption on the force of public opinion. The needs of modern life will force schools to adapt themselves to a scientific age Grammar-schools believe themselves to be immortal. Those curious immortals—the Struldbrugs— described by Swift, ultimately regretted their immortality, because they found themselves out of touch, sympathy, and fitness with the centuries in which they lived.

As there is no use clamouring for an instrument of more compass and power until we have made up our minds as to the tune, Professor Huxley, in his evidence before a Parliamentary Committee in 1884, has given a time-table for grammar-schools. He demands that out of their forty hours for public and private study ten should be given to modern languages and history, eight to arithmetic and mathematics, six to science, and two to geography, thus leaving fourteen hours to the dead languages. No time-table would, however, be suitable to all schools. The great public schools of England will continue to be the gymnasia for the upper classes, and should devote much of their time to classical and literary culture. Even now they introduce into their curriculum subjects unknown to them when the Royal

Commission of 1868 reported, though they still accept science with timidity. Unfortunately, the other grammar-schools which educate the middle classes look to the higher public schools as a type to which they should conform, although their functions are so different. It is in the interest of the higher public schools that this difference should be recognised, so that, while they give an all-round education and expand their curriculum by a freer recognition of the value of science as an educational power in developing the faculties of the upper classes, the schools for the middle classes should adapt themselves to the needs of their existence, and not keep up a slavish imitation of schools with a different function.

The stock argument against the introduction of modern subjects into grammar-schools is that it is better to teach Latin and Greek thoroughly rather than various subjects less completely. Is it true that thoroughness in teaching dead languages is the result of an exclusive system? In 1868 the Royal Commission stated that even in the few great public schools thoroughness was only given to 30 per cent. of the scholars, at the sacrifice of 70 per cent. who got little benefit from the system. Since then the curriculum has been widened and the teaching has improved. I question the soundness of the principle that it is better to limit the attention of the pupils mainly to Latin and Greek, highly as I value their educational power to a certain order of minds. As in biology the bodily development of animals is from the general to the special, so is it in the mental development of man. In the school a boy should be aided to discover the class of knowledge that is best suited for his mental capacities, so that, in the upper forms of the school and in the university, knowledge may be specialised in order to cultivate the powers of the man to their fullest extent. Shakespeare's educational formula may not be altogether true, but it contains a broad basis of truth—

> "No profit grows, where is no pleasure ta'en;—
> In brief, sir, study what you most affect."

The comparative failure of the modern side of school education arises from constituting it out of the boys who are looked upon as classical asses. Milton pointed out that in all schools there are boys to whom the dead languages are "like thorns and thistles," which form a poor nourishment even for asses. If teachers looked upon these classical asses as beings who might receive mental nurture according to their nature, much higher results would follow the bifurcation of our schools Saul went out to look for asses and he found a kingdom. Surely this fact is more encouraging than the example of Gideon, who "took thorns of the wilderness and briars, and with these he *taught* the men of Succoth."* The adaptation of public schools to a scientific age does not involve a contest as to whether science or classics shall prevail, for both are indispensable to true education. The real question is whether schools will undertake the duty of moulding the minds of boys according to their mental varieties Classics, from their structural perfection and power of awakening dormant faculties, have claims to precedence in education, but they have none to a practical monopoly. It is by claiming the latter that teachers sacrifice mental receptivity to a Procrustean uniformity.

The universities are changing their traditions more rapidly than the schools. The *via antiqua* which leads to them is still broad, though a *via moderna*, with branching avenues, is also open to their honours and emoluments. Physical science, which was once neglected, is now encouraged at the universities. As to the 70 per cent. of boys who leave schools for life-work without going through the universities, are there no growing signs of discontent

* Judges viii. 16.

which must force a change? The Civil Service, the learned professions, as well as the army and navy, are now barred by examinations. Do the boys of our public schools easily leap over the bars, although some of them have lately been lowered so as to suit the schools? So difficult are these bars to scholars that crammers take them in hand before they attempt the leap: and this occurs in spite of the large value attached to the dead languages and the small value placed on modern subjects. Thus in the Indian Civil Service examinations, 800 marks as a maximum are assigned to Latin, 600 to Greek, 500 to chemistry, and 300 to each of the other physical sciences. If we take the average working of the system for the last four years, we find that while 68 per cent of the maximum were given to candidates in Greek and Latin, only 45 per cent. were accorded to candidates in chemistry, and but 30 per cent. to the other physical sciences. Schools sending up boys for competition naturally shun subjects which are dealt with so hardly, and so heavily handicapped by the State.

Passing from learned or public professions to commerce, how is it that in our great commercial centres, foreigners—German, Swiss, Dutch, and even Greeks—push aside our English youth, and take the places of profit which belong to them by national inheritance? How is it that in our colonies, like those in South Africa, German enterprise is pushing aside English incapacity? How is it that we find whole branches of manufactures, when they depend on scientific knowledge, passing away from this country, in which they originated, in order to engraft themselves abroad, although their decaying roots remain at home? * The answer to these questions is that our systems of education are still too narrow for the increasing struggle of life.

* See Dr. Perkins' address to the Soc. Chem. Industry, "Nature," Aug. 6, 1885, p. 333.

Faraday, who had no narrow views in regard to education, deplored the future of our youth in the competition of the world, because, as he said with sadness, "our schoolboys, when they come out of school, are ignorant of their ignorance at the end of all that education."

The opponents of science education allege that it is not adapted for mental development, because scientific facts are often disjointed and exercise only the memory. Those who argue thus do not know what science is. No doubt an ignorant or half-informed teacher may present science as an accumulation of unconnected facts. At all times and in all subjects there are teachers without æsthetical or philosophical capacity—men who can only see carbonate of lime in a statue by Phidias or Praxiteles, who cannot survey zoology on account of its millions of species, or botany because of its 130,000 distinct plants, men who can look at trees without getting a conception of a forest, and cannot distinguish a stately edifice from its bricks. To teach in that fashion is like going to the tree of science with its glorious fruit in order to pick up a handful of the dry fallen leaves from the ground. It is, however, true that as science teaching has had less lengthened experience than that of literature, its methods of instruction are not so matured. Scientific and literary teaching have different methods; for while the teacher of literature rests on authority and on books for his guidance, the teacher of science discards authority, and depends on facts at first hand, and on the book of Nature for their interpretation. Natural science more and more resolves itself into the teaching of the laboratory. In this way it can be used as a powerful means of quickening observation, and of creating a faculty of induction after the manner of Zadig, the Babylonian described by Voltaire. Thus facts become surrounded by scientific conceptions, and are subordinated to order and law.

It is not those who desire to unite literature with science who degrade education; the degradation is the consequence of the refusal. A violent reaction—too violent to be wise—has lately taken place against classical education in France, where their own vernacular occupies the position of dead languages, while Latin and science are given the same time in the curriculum. In England manufacturers cry out for technical education, in which classical culture shall be excluded. In the schools of the middle classes science rather than technics is needed, because when the seeds of science are sown, technics as its fruit will appear at the appointed time. Epictetus was wise when he told us to observe that though sheep eat grass, it is not grass but wool that grows on their backs. Should, however, our grammar-schools persist in their refusal to adapt themselves to the needs of a scientific age, England must follow the example of other European nations, and found new modern schools in competition with them. For, as Huxley has put it, we cannot continue in this age "of full modern artillery to turn out our boys to do battle in it, equipped only with the sword and shield of an ancient gladiator." In a scientific and keenly competitive age an exclusive education in the dead languages is a perplexing anomaly. The flowers of literature should be cultivated and gathered, though it is not wise to send men into our fields of industry to gather the harvest when they have been taught only to cull the poppies and to push aside the wheat.

III.—Science and the Universities.

The State has always felt bound to alter and improve universities, even when their endowments are so large as to render it unnecessary to support them by public funds. When universities are poor, Parliament gives aid to them from imperial taxation. In this country that aid has been given with a very sparing hand. Thus the universities

and colleges of Ireland have received about £30,000 annually, and the same sum has been granted to the four universities of Scotland. Compared with imperial aid to foreign universities such sums are small. A single German University like Strasburg or Leipzig receives above £40,000 annually, or £10,000 more than all the colleges of Ireland or of Scotland. Strasburg, for instance, has had her university and its library rebuilt at a cost of £711,000, and receives an annual subvention of £43,000. In rebuilding the university of Strasburg eight laboratories have been provided, so as to equip it fully with the modern requirements for teaching and research.* Prussia, the most economical nation in the world, spends £391,000 yearly out of taxation on her universities.

The recent action of France is still more remarkable. Before the great Revolution France had twenty-three autonomous universities in the provinces. Napoleon desired to found one great university at Paris, and he crushed out the others with the hand of a despot, and remodelled the last with the instincts of a drill-sergeant. The central university sank so low that in 1868 it is said that only £8,000 were spent for true academic purposes. Startled by the intellectual sterility shown in the war, France has made gigantic efforts to retrieve her position, and has rebuilt the provincial colleges at a cost of £3,280,000, while her annual budget for their support now reaches half a million of pounds. In order to open these provincial colleges to the best talent of France, more than five hundred scholarships have been founded at an annual cost of £30,000. France now recognises that it is not by the

* The cost of these laboratories has been as follows: Chemical Institute, £35,000; Physical Institute, £28,000; Botanical Institute, £26,000; Observatory, £25,000; Anatomy, £42,000; Clinical Surgery, £26,000; Physiological Chemistry, 10,000; Physiological Institute, £13,900.

number of men under arms that she can compete with her great neighbour Germany, so she has determined to equal her in intellect. You will understand why it is that Germany was obliged, even if she had not been willing, to spend such large sums in order to equip the university of her conquered province, Alsace-Lorraine. France and Germany are fully aware that science is the source of wealth and power, and that the only way of advancing it is to encourage universities to make researches, and to spread existing knowledge through the community. Other European nations are advancing on the same lines. Switzerland is a remarkable illustration of how a country can compensate itself for its natural disadvantages by a scientific education of its people. Switzerland contains neither coal nor the ordinary raw materials of industry, and is separated from other countries which might supply them by mountain barriers. Yet, by a singularly good system of graded schools, and by the great technical college of Zurich, she has become a prosperous manufacturing country. In Great Britain we have nothing comparable to this technical college, either in magnitude or efficiency. Belgium is reorganising its universities, and the State has freed the localities from the charge of buildings, and will in future equip the universities with efficient teaching resources out of public taxation. Holland, with a population of 4,000,000 and a small revenue of £9,000,000, spends £136,000 on her four universities. Contrast this liberality of foreign countries in the promotion of higher instruction with the action of our own country. Scotland, like Holland, has four universities, and is not very different from it in population, but it only receives £30,000 from the State. By a special clause in the Scotch Universities Bill the Government asked Parliament to declare that under no circumstances should the Parliamentary grant be ever increased above £40,000. According to the views of the British Treasury there is a finality in science and in expanding knowledge.

The wealthy Universities of Oxford and Cambridge are gradually constructing laboratories for science. The merchant princes of Manchester have equipped their new Victoria University with similar laboratories. Edinburgh and Glasgow Universities have also done so, partly at the cost of Government and largely by private subscriptions. The poorer Universities of Aberdeen and St. Andrews are still inefficiently provided with the modern appliances for teaching science.

London has one small Government college and two chartered colleges, but is wholly destitute of a teaching university. It would excite great astonishment at the Treasury if we were to make the modest request that the great metropolis, with a population of four millions, should be put into as efficient academical position as the town of Strasburg with 104,000 inhabitants, by receiving, as that town does, £43,000 annually for academic instruction, and £700,000 for university buildings. Still, the amazing anomaly that London has no teaching university must ere long cease.

It is a comforting fact that, in spite of the indifference of Parliament, the large towns of the kingdom are showing their sense of the need of higher education. Manchester has already its university. Nottingham, Birmingham, Leeds, and Bristol have colleges more or less complete. Liverpool converts a disused lunatic asylum into a college for sane people. Cardiff rents an infirmary for a collegiate building. Dundee, by private benefaction, rears a Baxter College with larger ambitions. All these are healthy signs that the public are determined to have advanced science teaching, but the resources of the institutions are altogether inadequate to the end in view. Even in the few cases where the laboratories are efficient for teaching purposes, they are inefficient as laboratories for research. Under these circumstances the Royal Commission on Science advocates special

Government laboratories for research. Such laboratories supported by public money, are as legitimate subjects for expenditure as galleries for pictures or sculpture; but I think that they would not be successful, and would injure science if they failed. It would be safer in the meantime if the State assisted universities or well-established colleges to found laboratories of research under their own care. Even such a proposal shocks our Chancellor of the Exchequer, who tells us that this country is burdened with public debt, and has ironclads to build and arsenals to provide. Nevertheless our wealth is proportionally much greater than that of foreign States which are competing with so much vigour in the promotion of higher education. They deem such expenditure to be true economy, and do not allow their huge standing armies to be an apology for keeping their people backwards in the march of knowledge. France, which in the last ten years has been spending a million annually on university education, had a war indemnity to pay, and competes successfully with this country in ironclads. Either all foreign States are strangely deceived in their belief that the competition of the world has become a competition of intellect, or we are marvellously unobservant of the change which is passing over Europe in the higher education of the people. Preparations for war will not ensure to us the blessings and security of an enlightened peace. Protective expenditure may be wise, though productive expenditure is wiser.

> "Were half the powers which fill the world with terror,
> Were half the wealth bestowed on camps and courts
> Given to redeem the human mind from error—
> There were no need of arsenals and forts."

Universities are not mere storehouses of knowledge; they are also conservatories for its cultivation. In Mexico there is a species of ant which sets apart some of its

individuals to act as honey-jars by monstrously extending their abdomens to store the precious fluid till it is wanted by the community. Professors in a university have a higher function, because they ought to make new honey as well as to store it. The widening of the bounds of knowledge, literary or scientific, is the crowning glory of university life. Germany unites the functions of teaching and research in the universities, while France keeps them in separate institutions. The former system is best adapted to our habits, but its condition for success is that our science chairs should be greatly increased so that teachers should not be wholly absorbed in the duties of instruction. Germany subdivides the sciences into various chairs, and gives to the professors special laboratories. It also makes it a condition for the higher honours of a university that the candidates shall give proofs of their ability to make original researches. Under such a system, teaching and investigation are not incompatible. In the evidence before the Science Commission many opinions were given that scientific men engaged in research should not be burdened with the duties of education, and there is much to be said in support of this view when a single professor for the whole range of a physical science is its only representative in a university. I hope that such a system will not long continue, for if it do we must occupy a very inferior position as a nation in the intellectual competition of Europe. Research and education in limited branches of higher knowledge are not incompatible. It is true that Galileo complained of the burden imposed upon him by his numerous astronomical pupils, though few other philosophers have echoed this complaint. Newton, who produced order in worlds, and Dalton, who brought atoms under the reign of order and number, rejoiced in their pupils. Lalande spread astronomers as Liebig spread chemists, and Johannes Muller biologists, all over the world. Laplace, La Grange, Dulong, Gay-Lussac, Berthollet,

and Dumas, were professors as well as discoverers in France. In England our discoverers have generally been teachers. In fact I recollect only three notable examples of men who were not—Boyle, Cavendish, and Joule. It was so in ancient as well as in modern times, for Plato and Aristotle taught and philosophised. If you do not make the investigator a schoolmaster, as Dalton was, and as practically our professors are at the present time, with the duty of teaching all branches of their sciences, the mere elementary truths as well as the highest generalisations being compressed into a course, it is well that they should be brought into contact with the world in which they live, so as to know its wants and aspirations. They could then quicken the pregnant minds around them, and extend to others their own power and love of research. Goethe had a fine perception of this when he wrote—

> "Wer in der Weltgeschichte lebt,
> Wer in die Zeiten schaut, und strebt,
> Nur der ist werth, zu sprechen und zu dichten."

Our universities are still far from the attainment of a proper combination of their resources between teaching and research. Even Oxford and Cambridge, which have done so much in recent years in the equipment of laboratories and in adding to their scientific staff, are still far behind a second class German university The professional faculties of the English universities are growing, and will diffuse a greater taste for science among their students, though they may absorb the time of the limited professoriate so as to prevent it advancing the boundaries of knowledge. Professional faculties are absolutely essential to the existence of universities in poor countries like Scotland and Ireland. This has been the case from the early days of the Bologna University up to the present time. Originally universities arose not by mere bulls of popes, but as a response to the

strong desire of the professional classes to dignify their crafts by real knowledge. If their education had been limited to mere technical schools like the Medical School of Salerno which flourished in the eleventh century, length but not breadth would have been given to education. So the universities wisely joined culture to the professional sciences. Poor countries like Scotland and Ireland must have their academic systems based on the professional faculties, although wealthy universities like Oxford and Cambridge may continue to have them as mere supplements to a more general education. A greater liberality of support on the part of the State in the establishment of chairs of science, for the sake of science and not merely for the teaching of the professions, would enable the poorer universities to take their part in the advancement of knowledge.

I have already alluded to the foundation of new colleges in different parts of the kingdom. Owens College has worthily developed into the Victoria University. Formerly she depended for degrees on the University of London. No longer will she be like a moon reflecting cold and sickly rays from a distant luminary, for in future she will be a sun, a centre of intelligence, warming and illuminating the regions around her. The other colleges which have formed themselves in large manufacturing districts are remarkable expressions from them that science must be promoted. Including the colleges of a high class, such as University College and King's College in London, and the three Queen's Colleges in Ireland, the aggregate attendance of students in colleges without university rank is between nine and ten thousand, while that of the universities is fifteen thousand. No doubt some of the provincial colleges require considerable improvement in their teaching methods; sometimes they unwisely aim at a full university curriculum when it would be better for them to act as faculties. Still, they are all

growing in the spirit of self-help, and some of them are destined, like Owens College, to develop into universities. This is not a subject of alarm to lovers of education, while it is one of hope and encouragement to the great centres of industry. There are too few autonomous universities in England in proportion to its population. While Scotland, with a population of three and three-quarter millions, has four universities with 6,500 students, England, with twenty-six millions of people, has only the same number of teaching universities with 6,000 students. Unless English colleges have such ambition, they may be turned into mere mills to grind out material for examinations and competitions. Higher colleges should always hold before their students that knowledge, for its own sake, is the only object worthy of reverence. Beyond college life there is a land of research flowing with milk and honey for those who know how to cultivate it. Colleges should at least show a Pisgah view of this Land of Promise, which stretches far beyond the Jordan of examinations and competitions.

IV.—Science and Industry.

In the popular mind the value of science is measured by its applications to the useful purposes of life. It is no doubt true that science wears a beautiful aspect when she confers practical benefits upon man. But truer relations of science to industry are implied in Greek mythology. Vulcan, the god of industry, wooed science, in the form of Minerva, with a passionate love, but the chaste goddess never married, although she conferred upon mankind nearly as many arts as Prometheus, who, like other inventors, saw civilisation progressing by their use while he lay groaning in want on Mount Caucasus. The rapid development of industry in modern days depends on the applications of scientific knowledge, while its slower growth in former times was due

to experiments being made by trial and error in order to gratify the needs of man. Then an experiment was less a questioning of Nature than an exercise on the mind of the experimentalist. True questioning of Nature only arises when intellectual conceptions of the causes of phenomena attach themselves to ascertained facts as well as to their natural environments. Much real science had at one time accumulated in Egypt, Greece, Rome, and Arabia, though it became obscured by the intellectual darkness which spread over Europe like a pall for many centuries. The mental results of Greek science, filtered through the Romans and Arabians, gradually fertilised the soil of Europe. Even in ages which are deemed to be dark and unprolific, substantial though slow progress was made. By the end of the fifteenth century the mathematics of the Alexandrian school had become the possession of Western Europe; Arabic numerals, algebra, trigonometry, decimal reckoning, and an improved calendar, having been added to its stock of knowledge. The old discoveries of Democritus and Archimedes in physics, and of Hipparchus and Ptolemy in astronomy, were producing their natural developments, though with great slowness. Many manufactures, growing chiefly by experience, and occasionally lightened up by glimmerings of science throughout the prevailing darkness, had arisen before the sixteenth century. A knowledge of the properties of bodies, though scarcely of their relations to each other, came through the labours of the alchemists, who had a mighty impulse to work, for by the philosopher's stone, often not larger than half a rape-seed, they hoped to attain the three sensuous conditions of human enjoyment—gold, health, and immortality. By the end of the fifteenth century many important manufactures were founded by empirical experiment, with only the uncertain guidance of science. These manufactures arose from an increased knowledge of facts, around which scientific conceptions were slowly

concreting. Aristotle defines this as science when he says, "Art begins when, from a great number of experiences, one general conception is formed which will embrace all similar cases." Such conceptions are formed only when culture develops the human mind and compels it to give a rational account of the world in which man lives, and of the objects in and around it, as well as of the phenomena which govern their action and evolution. Though the accumulation of facts is indispensable to the growth of science, a thousand facts are of less value to human progress than is a single one when it is scientifically comprehended, for it then becomes generalised in all similar cases. Isolated facts may be viewed as the dust of science. The dust which floats in the atmosphere is to the common observer mere incoherent matter in wrong place, while to the man of science it is all-important when the rays of heat and light act upon its floating particles. It is by them that clouds and rains are influenced; it is by their selective influence on the solar waves that the blue of the heavens and the beauteous colours of the sky glorify all Nature. So, also, ascertained though isolated facts, forming the dust of science, become the reflecting media of the light of knowledge, and cause all Nature to assume a new aspect. It is with the light of knowledge that we are enabled to question Nature through direct experiment. The hypothesis or theory which induces us to put the experimental question may be right or wrong; still, *prudens quæstio dimidium scientiæ est*: it is half way to knowledge when you know what you have to inquire. Davy described hypothesis as the mere scaffolding of science, useful to build up true knowledge, but capable of being put up or taken down at pleasure. Undoubtedly a theory is only temporary, and the reason is, as Bacon has said, that the man of science "loveth truth more than his theory." The changing theories which the world despises are the leaves of the tree of science drawing nutriment to the parent

stems, and enabling it to put forth new branches and to produce fruit; though the leaves fall and decay, the very products of decay nourish the roots of the tree and reappear in the new leaves or theories which succeed.

When the questioning of Nature by intelligent experiment has raised a system of science, then those men who desire to apply it to industrial inventions proceed by the same methods to make rapid progress in the arts. They also must have means to compel Nature to reveal her secrets. Æneas succeeded in his great enterprise by plucking a golden branch from the tree of science. Armed with this, even dread Charon dared not refuse him a passage across the Styx: and the gate of the Elysian fields was unbarred when he hung the branch on its portal. Then new aspects of Nature were revealed—

> "Another sun and stars they know
> That shine like ours, but shine below."

It is by carrying such a golden branch from the tree of science that inventors are able to advance the arts. In illustration of how slowly at first and how rapidly afterwards science and its applications arise, I will take only two out of thousands of examples which lie ready to my hand. One of the most familiar instances is air, for that surely should have been soon understood if man's unaided senses are sufficient for knowledge. Air has been under the notice of mankind ever since the first man drew his first breath. It meets him at every turn; it fans him with gentle breezes, and it buffets him with storms. And yet it is certain that this familiar object—air—is very imperfectly understood up to the present time. We now know by recent researches that air can be liquefied by pressure and cold; but as a child still looks upon air as nothing, so did man in his early state. A vessel filled with air was deemed to be empty. Man, as soon as he began to speculate, felt the importance of air, and deemed

it to be a soul of the world upon which the respiration of man and the god-like quality of fire depended. Yet a really intelligent conception of these two essential conditions to man's existence—respiration and combustion—was not formed till about a century ago (1775). No doubt long before that time there had been abundant speculations regarding air. Anaximenes, 548 years before Christ, and Diogenes of Apollonia, a century later, studied the properties of air so far as their senses would allow them; so, in fact, did Aristotle. Actual scientific experiments were made on air about the year 1100 by a remarkable Saracen, Alhazen, who ascertained important truths which enabled Galileo, Torricelli, Otto de Guericke, and others, at a later period to discover laws leading to important practical applications. Still there was no intelligent conception as to the composition of air until Priestley in 1774 repeated, with the light of science, an empirical observation which Eck de Sulbach had made three hundred years before upon the union of mercury with an ingredient of air and the decomposition of this compound by heat. This experiment now proved that the active element in air is oxygen. From that date our knowledge, derived from an intelligent questioning of air by direct experiments, has gone on by leaps and bounds. The air, which mainly consists of nitrogen and oxygen, is now known to contain carbonic acid, ammonia, nitric acid, ozone, besides hosts of living organisms which have a vast influence for good or evil in the economy of the world. These micro-organisms, the latest contribution to our knowledge of air, perform great analytical functions in organic nature, and are the means of converting much of its potential energy into actual energy. Through their action on dead matter the mutual dependence of plants and animals is secured.

The consequences of the progressive discoveries have added largely to our knowledge of life, and have given a marvellous development to the industrial arts. Combustion

and respiration govern a wide range of processes. The economical use of fuel, the growth of plants, the food of animals, the processes of husbandry, the maintenance of public health, the origin and cure of disease, the production of alcoholic drinks, the methods of making vinegar and saltpetre—all these and many other kinds of knowledge have been brought under the dominion of the law. No doubt animals respired, fuel burned, plants grew, sugar fermented, before we knew how they depended upon air. As the knowledge was empirical, it could not be intelligently directed. Now all these processes are ranged in order under a wise economy of Nature, and can be directed to the utilities of life; for it is true, as Swedenborg says, that "human ends always ascend as Nature descends." There is scarcely a large industry in the world which has not received a mighty impulse by the better knowledge of air acquired within a hundred years. If I had time I could show still more strikingly the industrial advantages which have followed from Cavendish's discovery of the composition of water. I wish that I could have done this, because it was Addison who foolishly said, and Paley who as unwisely approved the remark, "that mankind required to know no more about water than the temperature at which it froze and boiled, and the mode of making steam."

When we examine the order of progress in the arts, even before they are illuminated by science, their improvements seem to be the resultants of three conditions.

1. The substitution of natural forces for brute animal power, as when Hercules used the waters of the Alpheus to cleanse the Augean stables; or when a Kamchadal of Eastern Asia, who has been three years hollowing out a canoe, finds that he can do it in a few hours by fire.

2. The economy of time, as when a calendering machine produces the same gloss to miles of calico that an African savage gives to a few inches by rubbing it with the shell of a

snail; or the economy of production, as when steel pens, sold when first introduced at one shilling apiece, are now sold at a penny per dozen; or when steel rails, lately costing £45 per ton, can now be sold at £5.

3. Methods of utilising waste products, or of endowing them with properties which render them of increased value to industry, as when waste scrap iron and the galls on the oak are converted into ink; or the badly-smelling waste of gasworks is transformed into fragrant essences, brilliant dyes, and fertilising manure; or when the effete matter of animals or old bones is changed into lucifer-matches.

All three results are often combined when a single end is obtained—at all events, economy of time and production invariably follows when natural forces substitute brute animal force. In industrial progress the sweat of the brow is lessened by the conceptions of the brain. How exultant is the old Greek poet, Antipater,* when women are relieved of the drudgery of turning the grindstones for the daily supply of corn. "Woman! you who have hitherto had to grind corn, let your arms rest for the future. It is no longer for you that the birds announce by their songs the dawn of the morning. Ceres has ordered the *water-nymphs* to move the heavy millstones and perform your labour." Penelope had twelve slaves to grind corn for her small household. During the most prosperous time of Athens it was estimated that there were twenty slaves to each free citizen. Slaves are mere machines, and machines neither invent nor discover. The bondmen of the Jews, the helots of Sparta, the captive slaves of Rome, the serfs of Europe, and uneducated labourers of the present day who are the slaves of ignorance, have added nothing to human progress. As natural forces substitute and become cheaper than slave labour, liberty follows advancing civilisation. Machines require educated

* *Analecta Veterum Græcorum*, Epig. 39, vol. ii. p. 119.

superintendence. One shoe factory in Boston by its machines does the work of thirty thousand shoemakers in Paris who have still to go through the weary drudgery of mechanical labour. The steam power of the world, during the last twenty years, has risen from eleven and a half million to twenty-nine million horse-power, or 152 per cent.

Let me take a single example of how even a petty manufacture, improved by the teachings of science, affects the comforts and enlarges the resources of mankind. When I was a boy, the only way of obtaining a light was by the tinder-box, with its quadruple materials, flint and steel, burnt rags or tinder, and a sulphur-match. If everything went well, if the box could be found and the air was dry, a light could be obtained in two minutes: but very often the time occupied was much longer, and the process became a great trial to the serenity of temper. The consequence of this was that a fire or a burning lamp was kept alight through the day. Old Gerard, in his "Herbal," tells us how certain fungi were used to carry fire from one part of the country to the other. The tinder-box long held its position as a great discovery in the arts. The *Pyxidicula Ignaria* of the Romans appears to have been much the same implement, though a little ruder, than the flint and steel which Philip the Good put into the collar of the Golden Fleece in 1429 as a representation of high knowledge in the progress of the arts. It continued to prevail till 1833, when phosphorus-matches were introduced, though I have been amused to find that there are a few venerable ancients in London who still stick to the tinder-box, and for whom a few shops keep a small supply. Phosphorus was no new discovery, for it had been obtained by an Arabian called Bechel in the eighth century. However, it was forgotten, and was re-discovered by Brandt, who made it out of very stinking materials in 1669. Other discoveries had, however, to be made before it could be used for lucifer-matches. The science of combustion was only

developed on the discovery of oxygen a century later. Time had to elapse before chemical analysis showed the kind of bodies which could be added to phosphorus so as to make it ignite readily. So it was not till 1833 that matches became a partial success. Intolerably bad they then were, dangerously inflammable, horribly poisonous to the makers, and injurious to the lungs of the consumers. It required another discovery by Schrötter, in 1845, to change poisonous waxy into innocuous red-brick phosphorus in order that these defects might be remedied, and to give us the safety-match of the present day. Now what have these successive discoveries in science done for the nation, in this single manufacture, by an economy of time? If before 1833 we had made the same demands for light that we now do, when we daily consume eight matches per head of the population, the tinder-box could have supplied the demand under the most favourable conditions by an expenditure of one quarter of an hour. The lucifer-match supplies a light in fifteen seconds on each occasion, or in two minutes for the whole day. Putting these differences into a year, the venerable ancient who still sticks to his tinder-box would require to spend ninety hours yearly in the production of light, while the user of lucifer-matches spends twelve hours; so that the latter has an economy of seventy-eight hours yearly, or about ten working days. Measured by cost of production at one shilling and sixpence daily, the economy of time represented in money to our population is twenty-six millions of pounds annually. This is a curious instance of the manner in which science leads to economy of time and wealth even in a small manufacture. In larger industries the economy of time and labour produced by the application of scientific discoveries is beyond all measurement. Thus the discovery of latent heat by Black led to the inventions of Watt; while that of the mechanical equivalent of heat by Joule has been the basis of the progressive improvements in the steam-engine

which enables power to be obtained by a consumption of fuel less than one-fourth the amount used twenty years ago. It may be that the engines of Watt and Stephenson will yield in their turn to more economical motors; still they have already expanded the wealth, resources, and even the territories of England, more than all the battles fought by her soldiers, or all the treaties negotiated by her diplomatists.

The coal which has hitherto been the chief source of power probably represents the product of five or six million years during which the sun shone upon the plants of the carboniferous period, and stored up its energy in this convenient form. We are using this conserved force wastefully and prodigally; for although horse-power in steam engines has so largely increased since 1864, we only apply a small portion of the power existing in coal. It is only three hundred years since we became a manufacturing country. According to Professor Dewar, in less than two hundred years more the coal of this country will be wholly exhausted, and in half that time will be difficult to procure. Our not very distant descendants will have to face the problem—What will be the condition of England without coal? The answer to that question depends upon the intellectual development of the nation at that time. The value of the intellectual factor of production is continually increasing; while the values of raw material and fuel are lessening factors. It may be that when the dreaded time of exhausted fuel has arrived, its importation from other coal-fields, such as those of New South Wales, or the supply of petroleum from America or the borders of the Caspian Sea, will be so easy and cheap, that the increased technical education of our operatives may largely overbalance the disadvantages of increased cost in fuel. But this supposes that future Governments in England will have more enlightened views as to the value of science than past Governments have possessed.

Industrial applications are but the overflowings of science welling over from the fulness of its measure. Few would ask now, as was constantly done a few years ago, "What is the use of an abstract discovery in science?" Faraday once answered this question by another, "What is the use of a baby?" Yet round that baby centre all the hopes and sentiments of his parents, and even the interests of the State, which interferes in its upbringing so as to ensure it being a capable citizen. The processes of mind which produce a discovery or an invention are rarely associated in the same person, for while the discoverer seeks to explain causes and the relations of phenomena, the inventor aims at producing new effects, or at least of obtaining them in a novel and efficient way. In this the inventor may sometimes succeed without much knowledge of science, though his labours are infinitely more productive when he understands the causes of the effects which he desires to produce.

A nation in its industrial progress, when the competition of the world is keen, cannot stand still. Three conditions only are possible for it. It may go forward, retrograde, or perish. Its extinction as a great nation follows its neglect of higher education, for, as described in the proverb of Solomon, "They that hate instruction love death." In sociology, as in biology, there are three states. The first of balance, when things grow neither better nor worse; the second that of elaboration or evolution, as we see it when animals adapt themselves to their environments, and third, that of degeneration, when they rapidly lose the ground they have made. For a nation, a state of balance is only possible in the early stage of its existence, but it is impossible when its environments are constantly changing.

The possession of the raw materials of industry and the existence of a surplus population are important factors for the growth of manufactures in the early history of a nation, but afterwards they are bound up with another factor—the

application of intellect to their development. England could not be called a manufacturing nation till the Elizabethan age. No doubt coal, iron, and wool, were in abundance, though, in the reign of the Plantagenets, they produced little prosperity. Wool was sent to Flanders to be manufactured, for England then stood to Holland as Australia now does to Yorkshire. The political crimes of Spain from the reign of Ferdinand and Isabella to that of Philip III. destroyed it as a great manufacturing nation, and indirectly led to England taking its position. After that period cotton mixed with linen and wool became freely used, but it was only from 1738 to the end of the century that the inventions of Wyatt, Arkwright, Hargreaves, Crompton, and Cartwright, started the wonderful modern development. The raw cotton was imported from India or America, though that fact as regards costs was a small factor in comparison with the intellect required to convert it into a utility. Science has, in the last hundred years, altered altogether the old conditions of industrial competition. She has taught the rigid metals to convey and record our thoughts even to the most distant lands, and, within less limits to reproduce our speech. This marvellous application of electricity has diminished the cares and responsibilities of Governments, while it has at the same time altered the whole practice of commerce. To England steam and electricity have been of incalculable advantage. The ocean, which once made the country insular and isolated, is now the very life-blood of England and of the greater England beyond the seas. As in the human body the blood bathes all its parts, and through its travelling corpuscles carries force to all its members, so in the body politic of England and its pelagic extensions, steam has become the circulatory and electricity the nervous system. The colonies, being young countries, value their raw materials as their chief sources of wealth. When they become older they will

discover it is not in these, but in the culture of scientific intellect, that their future prosperity depends. Older nations recognise this as the law of progress more than we do; or, as Jules Simon tersely puts it—"That nation which most educates her people will become the greatest nation, if not to-day, certainly to-morrow." Higher education is the condition of higher prosperity, and the nation which neglects to develop the intellectual factor of production must degenerate, for it cannot stand still. If we felt compelled to adopt the test of science given by Comte, that its value must be measured by fecundity, it might be prudent to claim industrial inventions as the immediate fruit of the tree of science, though the only fruit which the prolific tree has shed. The test is untrue in the sense indicated, or rather the fruit, according to the simile of Bacon, is like the golden apples which Aphrodite gave to the suitor of Atalanta, who lagged in her course by stooping to pick them up, and so lost the race. The true cultivators of the tree of science must seek their own reward by seeing it flourish, and let others devote their attention to the possible practical advantages which may result from their labours.

There is, however, one intimate connection between science and industry which I hope will be more intimate as scientific education becomes more prevalent in our schools and universities. Abstract science depends on the support of men of leisure, either themselves possessing or having provided for them the means of living without entering into the pursuits of active industry. The pursuit of science requires a superfluity of wealth in a community beyond the needs of ordinary life. Such superfluity is also necessary for art, though a picture or a statue is a saleable commodity, while an abstract discovery in science has no immediate, or, as regards the discoverer, proximate commercial value. In Greece, when philosophical and scientific speculation was at its highest point, and when education

was conducted in its own vernacular, and not through dead languages, science, industry, and commerce were actively prosperous. Their philosophers were the sons of burghers, and generally carried on the trades of their fathers. Now, if our universities and schools created that love of science which a broad education would surely inspire, our men of riches and leisure who advance the boundaries of scientific knowledge could not be counted on the fingers as they now are, when we think of Boyle, Cavendish, Napier, Lyell, Murchison, and Darwin, but would be as numerous as our statesmen and orators. Statesmen, without a following of the people who share their views and back their work, would be feeble indeed. But while England has never lacked leaders in science, they have too few followers to risk a rapid march. We might create an army to support our generals in science, as Germany has done, and as France is now doing, if education in this country would only mould itself to the needs of a scientific age. It is with this feeling that Horace Mann wrote :—"The action of the mind is like the action of fire; one billet of wood will hardly burn alone, though as dry as the sun and north-west wind can make it, and though placed in a current of air; ten such billets will burn well together, but a hundred will create a heat fifty times as intense as ten—will make a current of air to fan their own flame, and consume even greenness itself."

V.—Abstract Science the Condition for Progress.

The subject of my address has been the relations of science to the public weal. That is a very old subject to select for the year 1885. I began it by quoting the words of an illustrious prince, the consort of our Queen, who addressed us on the same subject from this platform twenty-six years ago. He was not the first prince who saw how closely science is bound up with the welfare of States. Ali, the son-

in-law of Mahomet, the fourth successor to the Caliphate, urged upon his followers that men of science and their disciples give security to human progress. Ali loved to say, "Eminence in science is the highest of honours," and "He dies not who gives life to learning." In addressing you upon texts such as these, my purpose was to show how unwise it is for England to lag in the onward march of science when most other European Powers are using the resources of their States to promote higher education and to advance the boundaries of knowledge. English Governments alone fail to grasp the fact that the competition of the world has become a competition in intellect. Much of this indifference is due to our systems of education. I have ill fulfilled my purpose if, in claiming for science a larger share in public education, I have in any way depreciated literature, art, or philosophy, for every subject which adds to culture aids in human development. I only contend that in public education there should be a free play to the scientific faculty, so that the youths who possess it should learn the richness of their possession during the educative process. The same faculties which make a man great in any walk of life—strong love of truth, high imagination tempered by judgment, a vivid memory which can co-ordinate other facts with those under immediate consideration—all these are qualities which the poet, the philosopher, the man of literature, and the man of science, equally require and should cultivate through all parts of their education as well as in their future careers. My contention is that science should not be practically shut out from the view of a youth while his education is in progress, for the public weal requires that a large number of scientific men should belong to the community. This is necessary because science has impressed its character upon the age in which we live, and as science is not stationary but progressive, men are required to advance its boundaries,

acting as pioneers in the onward march of States. Human progress is so identified with scientific thought, both in its conception and realisation, that it seems as if they were alternative terms in the history of civilisation. In literature, and even in art, a standard of excellence has been attained which we are content to imitate because we have been unable to surpass. There is no such standard in science. Formerly, when the dark cloud was being dissipated which had obscured the learning of Greece and Rome, the diffusion of literature or the discovery of lost authors had a marked influence on advancing civilisation. Now, a Chrysoloras might teach Greek in the Italian universities without hastening sensibly the onward march of Italy; a Poggio might discover copies of Lucretius and Quintilian without exercising a tithe of the influence on modern life that an invention by Stephenson or Wheatstone would produce. Nevertheless, the divorce of culture and science, which the present state of education in this country tends to produce, is deeply to be deplored, because a cultured intelligence adds greatly to the development of the scientific faculty. My argument is that no amount of learning without science suffices in the present state of the world to put us in a position which will enable England to keep ahead or even on a level with foreign nations as regards knowledge and its applications to the utilities of life. Take the example of any man of learning, and see how soon the direct consequences resulting from his learning disappear in the life of a nation, while the discoveries of a man of science remain productive amid all the shocks of empire. As I am in Aberdeen, I remember that the learned Dutchman Erasmus was introduced to England by the encouragement which he received from Hector Boece, the Principal of King's College in this university. Yet even in the case of Erasmus—who taught Greek at Cambridge, and did so much for the revival of classical literature as well as in the promotion of spiritual freedom—

how little has civilisation to ascribe to him in comparison with the discoveries of two other Cambridge men, Newton and Cavendish. The discoveries of Newton will influence the destinies of mankind to the end of the world. When he established the laws by which the motions of the great masses of matter in the universe are governed, he conferred an incalculable benefit upon the intellectual development of the human race. No great discovery flashes upon the world at once, and therefore Pope's lines on Newton are only a poetic fancy :—

> "Nature and Nature's laws lay hid in night,
> God said, 'Let Newton be,' and all was light."

No doubt the road upon which he travelled had been long in preparation by other men. The exact observations of Tycho Brahe, coupled with the discoveries of Copernicus, Kepler, and Galileo, had already broken down the authority of Aristotle and weakened that of the Church. Though the conceptions of the universe were thus broadened, mankind had not yet rid themselves of the idea that the powers of the universe were still regulated by spirits or special providences. Even Kepler moved the planets by spirits, and it took some time to knock these celestial steersmen on the head. Descartes, who really did so much by his writings to force the conclusion that the planetary movements should be dealt with as an ordinary problem in mechanics, looked upon the universe as a machine, the wheels of which were kept in motion by the unceasing exercise of a divine power. Such theories were only an attempt to regulate the universe by celestial intelligences like our own, and by standards within our reach. It required the discovery of an all-pervading law, universal throughout all space, to enlarge the thoughts of men, and one which, while it widened the conceptions of the universe, reduced the earth and solar system to true dimensions. It is by the investiga-

tions of the finite on all sides that we obtain a higher conception of the infinite—

> "Willst du ins Unendliche schreiten,
> Geh nur im Endlichen nach allen Seiten."

Ecclesiastical authority had been already undermined by earnest inquirers such as Wycliffe and Huss before Luther shook the pillars of the Vatican. They were removers of abuses, but were confined within the circles of their own beliefs. Newton's discovery cast men's minds into an entirely new mould, and levelled many barriers to human progress. This intellectual result was vastly more important than the practical advantages of the discovery. It is true that navigation and commerce mightily benefited by our better knowledge of the motions of the heavenly bodies. Still, these benefits to humanity are incomparably less in the history of progress than the expansion of the human intellect which followed the withdrawal of the cramps that confined it. Truth was now able to discard authority, and marched forward without hindrance. Before this point was reached Bruno had been burned, Galileo had abjured, and both Copernicus and Descartes had kept back their writings for fear of offending the Church.

The recent acceptance of evolution in biology has had a like effect in producing a far profounder intellectual change in human thought than any mere impulse of industrial development. Already its application to sociology and education is recognised, though that is of less import to human progress than the broadening of our views of Nature.

Abstract discovery in science is then the true foundation upon which the superstructure of modern civilisation is built; and the man who would take part in it should study science, and if he can advance it for its own sake and not for its applications. Ignorance may walk in the path lighted

by advancing knowledge, but she is unable to follow when science passes her, for, like the foolish virgin, she has no oil in her lamp.

An established truth in science is like the constitution of an atom in matter—something so fixed in the order of things that it has become independent of further dangers in the struggle for existence. The sum of such truths forms the intellectual treasure which descends to each generation in hereditary succession. Though the discoverer of a new truth is a benefactor to humanity, he can give little to futurity in comparison with the wealth of knowledge which he inherited from the past. We, in our generation, should appreciate and use our great possessions—

> "For me your tributary stores combine,
> Creation's heir; the world, the world is mine."

PETROLEUM THE LIGHT OF THE POOR.

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PETROLEUM (*petri oleum*, rock oil) has, within the last generation, been the chief source of light to the poor classes in many countries, and soon it may compete with coal as a source of power in steamships and railways. It may, therefore, be interesting to the readers of this article to know some facts in regard to it from a writer who had some influence in bringing petroleum and its products into economic use in this country.

Petroleum has been known in some parts of the earth, where it occurs native, from the earliest periods of human history. The sacred fires of the sun-worshippers were fed by the gases which issue from it. The asphalte left by its evaporation was the basis of the mortar with which Nineveh and Babylon were built. It seems to be frequently referred to in the Bible, though biblical chemistry is much obscured by bad translation. As an instance of this, carbonate of soda, when referred to, is translated *nitre*, and is made to do things impossible to that substance. Thus Solomon tells us that as vinegar upon nitre, so is he that singeth songs to a heavy heart This has no meaning, for vinegar does nothing to nitre; but it causes a lively and unpleasant commotion when poured upon soda (*νιτρον*). So also when Jeremiah speaks of washing with nitre and soap, there is no meaning; though soda and soap are used constantly

in this relation. It is thus that petroleum in the Bible is concealed under the general word "salt." That word is both generic and specific in all countries. In the latter limited sense it is sea or kitchen salt. In the more general sense it includes a vast number of substances, of which Epsom salt and Glauber salt are familiar examples. The connection of salt with petroleum, in biblical language, begins early in Genesis, when the Dead Sea, or Lake of Sodom, is called the Salt Sea. That sea abounds in petroleum springs, and has asphalte on its ancient shores. Accordingly it has also been called the Lake *Asphaltites*. Many things become comprehensible if we take the generic term "salt," and apply it to petroleum and its residue, asphalte. Lot's wife, if converted into a pillar of common salt, would have been washed away by the first shower of rain; but a pillar of asphalte, even as a memorial of her, would have been an enduring monument, and might have been seen by Josephus and his contemporary, Clement of Rome, both of whom declare that they saw it. So also when we are told by Mark that "every one shall be salted with fire, and every sacrifice shall be salted with salt," I see a meaning only when I recollect that, in regions containing petroleum, sacrificial fires were fed with this fuel to aid the burning. In like manner, when Matthew likens the blessed, first to salt, and immediately afterwards to a lighted torch (for candles, as translated, were then unknown), I see the connection in his mind. He had just said that salt which had lost its savour was only fit to be trodden under foot of men. Now salt never does lose its savour, and is never fit to be trodden under foot. But petroleum does lose its essence by exposure, and out of the residue the ancients used to make asphalte pavements, as they do at the present day. I only give some reasons for my belief that the salt of the Bible, in its generic sense, was often applied to petroleum; but I admit at the same time that the readers of

this article ought not to attach much importance to my opinions on any subject of biblical criticism. In the Apocrypha petroleum is called "thick water." There is a remarkable description of it in Maccabees (Macc. II. ch. i. vv. 19 to 36). It shows not only how it was used in burnt sacrifices, but also how the modern word "naphtha" arose. Neemias was searching for the sacred fire and was taken to a pit in which there was "thick water." This he poured on the sacrifice, and when the sun came from behind a cloud, it took fire, and burnt the sacrifice. "And Neemias called this thing Napthar, which is as much as to say a cleansing: but many men call it Nephi"

Petroleum occurs as a greenish or dark-coloured fluid in many countries. In small quantity it occasionally occurs in England. I found a well of it in Derbyshire in 1846, and induced the late Mr. Young to establish a manufactory of burning oil, and ultimately of paraffin candles. This suggestion led gradually, in his energetic hands, to the great petroleum industry which has carried cheap light into the houses of the poor. The small supply of native petroleum of Derbyshire soon became exhausted, but the discovery that it could be distilled out of Boghead coal and bituminous shales gave a great impulse to its manufacture. In 1859 America began to introduce native petroleum from Pennsylvanian wells. During that year eighty thousand barrels were supplied to commerce, and that quantity was thought to be immense, though it was insignificant compared with the present supply, which has reached seventy-seven million gallons. Other copious supplies of native petroleum have been found in India, Burmah, and the Caucasian lands about the Caspian Sea. The last source of supply is of such extraordinary magnitude that I will refer to it more in detail at a later part of this article. I may mention, however, that at Surakhani, on the western shore of the Caspian, sacred fires have been burning probably longer than recorded

history. The priests allege that the fires in their temple, fed by gas issuing from the petroleum below, have burned without cessation since four hundred years before Christ.

Before, however, describing the uses of petroleum, I ought to say something as to its probable origin. This is not thoroughly understood. When we prepare artificial petroleum, we distil, at a low red heat, the remains of organic substances such as highly bituminous coals or shales. We know that coal has been produced by plant life, so, when we extract petroleum from it, we naturally look to organic matters as its ultimate source. Nevertheless, petroleum occurs in many geological formations where organic life has only sparsely existed. If petroleum be a result of a slow distillation of organic matter, where are the residues of distillation? They are never found in the borings for wells. Nor does petroleum when examined by the microscope exhibit the least traces of organised structures.

The range of geological formations in which petroleum is found is considerable. In the Caspian Sea it is found in tertiary sands, having a comparatively modern origin in a geological sense. But, in Canada, it occurs as low down as the Silurian formation and in the lower parts of the Devonian while in Pennsylvania it is in the upper series of the Devonian, below the coal measures. An elementary knowledge of geology shows us that these facts render it difficult to connect petroleum with pre-existing organic *débris*. Ordinary rocks result from the waste of pre-existing systems, or are pushed up by volcanic energy from central depths. Neptunists could not explain the formation of petroleum by aqueous action; for it is so light that it would float on the top of water, and would not be buried by deposit. Vulcanists of the old school would be equally perplexed, because petroleum is so volatile that heat would convert it into vapour, and it would be dissipated. Indeed, I recollect an instance of this kind in a quarry near Dysart,

in Fifeshire, where every fragment of stone freshly-broken smelt of petroleum.

Is then petroleum cosmic? Perhaps the question is not so absurd as it appears. Recent observations on the tail of the great comet which adorned the heavens not long since showed that it contained hydrocarbons very similar to petroleum. I do not mean to indicate that the comet was a huge petroleum lamp rushing through space, still, the detection of hydrocarbons in it is a significant fact. It lends considerable support to the idea that petroleum is being continually formed anew in the deeper parts of the earth. In all petroleum wells water is also found In the depths of the earth there is probably a large abundance of compounds of the metals with carbon, for we find them in basaltic and other rocks. When the crust of the earth becomes fissured, water would reach these at a high temperature, and be decomposed, its oxygen passing over to the metals, while the carbon and hydrogen would unite to produce hydrocarbons, the most common form of which is petroleum The gaseous hydrocarbons, formed by the same action, are pent up in these cavities, and, when a boring is made for a well, force up the petroleum frequently as high fountains. Wells of this substance are generally found at the base of mountain ranges, as of the Alleghanies in America, or of the Caucasus in Russia. These elevations indicate cavities, fissures, or crevasses below, and into these, as into a receiver, the hydrocarbons may have been distilled and become condensed. This is only a theory, but it is the one which is the most satisfactory to my mind, and if it be true, it is a comforting one, for while we find forests disappearing from the earth, and coal being exhausted without being formed afresh, petroleum, which as fuel has about twice the value of coal, is being constantly formed and deposited in nature's reservoirs. I have admitted that this is nothing more than a theory, and, as such, the practical mind is accustomed to

look upon it with contempt. Theory is the best explanation of all known facts. We probably may soon have a better theory, and when it comes I will embrace it.

If I am asked to define petroleum, I should have to answer by giving a general chemical formula which, at first sight, might look puzzling. It belongs to the series of hydrocarbons, $C^n. H^{2n+2}$, or to a group of bodies containing double the atoms of hydrogen to those of carbon, with two more of hydrogen in addition. It contains rather more hydrogen than olefiant gas, the chief illuminating agent of coal gas, for that and its numerous congeners have the general formula $C^n. H^{2n}$. The need of such a general formula as I have given for the complex fluid called petroleum is manifest when I state that it contains members of the same family of hydrocarbons varying from the solid paraffin, with which all ordinary candles are now made, to the most volatile liquids nearly resembling gases. Here I cannot help interpolating an anecdote as to how paraffin candles were thought of. This solid wax from tar had been discovered by Reichenbach, but was so rare when I first became Professor of Chemistry that I was proud in having a quarter of an ounce in a bottle to show my students. One cold day Mr. Young called upon me with some Derbyshire petroleum, and asked me what I thought the solid crystals floating in it could be. I answered that they must be paraffin, and asked whether he could not prepare sufficient for me to make two candles. With these I lighted the desk on the lecture table of the Royal Institution, and pointed out that though the cost of these candles was more than twenty shillings each, yet before long they would become the common candle of the country. This safe prophecy has long since been realised, for paraffin is now manufactured in thousands of tons annually. There is an island on the eastern side of the Caspian Sea called Tcheliken, where the very cliffs are stated to be composed

of crude paraffin, or "ozokerit;" while east of Krasnovodsk, on the same shore, "there are immense hills of ozokerit and petroleum," according to the statements of travellers. Intermediate between the solid paraffin and burning oil there is another oil fitted for lubricating machinery. In some kinds of petroleum and paraffin oil distilled from shale this is neither important in quantity or in quality, though in the heavier kinds of petroleum, such as that of the Caucasian range, it exists in abundance. Besides this lubricating oil, there is also in the tars, at present barbarously rejected as useless, volatile benzole and certain solids known as naphthaline and anthracene. From the benzole can be made those beautiful aniline colours known as mauve and magenta; while out of the solid naphthaline and anthracene can be prepared alizarin, the red colour of madder, and also indigo, the staple blue dye. In the future development of the native petroleum industry these higher products are likely to be a very important branch of production. As competition becomes keen, these waste products may become the largest source of profit.

Thus it will be seen how largely petroleum has become an article of industrial necessity, and how much more it will enter into manufactures when the present waste products of the heavier kinds are applied, as they are sure to be, to the preparation of staple colours, such as alizarin and indigo. For the present, however, the great consumption of petroleum, whether it is found naturally, or made artificially, as in Scotland, by the distillation of bituminous shales, is for the production of light. I have explained already that though it contains a little more hydrogen than olefiant gas, it may, for all practical purposes, be viewed as essentially belonging to the group of "olifenes." Now, as olefiant gas is the chief illuminating ingredient of rich coal gas, refined petroleum, as well as solid paraffin, made into candles may be looked upon as representative of all that is illuminating in coal gas,

without being diluted or contaminated by unnecessary ingredients. A paraffin candle is in reality a portable gas machine. The charred fibres of the wick are the retorts in which the gas is manufactured for use, just in proportion as it is wanted. A petroleum lamp is the same little gas factory, in which the oil is sucked up by the capillary attraction of the wick, and there is converted into gas just in proportion to its requirements. Unluckily ordinary refined petroleum has an offensive smell, though this is gradually disappearing as the manufacture improves. In the better varieties, now burned in good houses under the name of crystal or water oil, there is little to be desired in this respect.

In America, where the abundance of petroleum leads to considerable inventiveness in its use, I have seen applications of it which have only recently been adopted in this country. I happened, this autumn, to visit various large houses in country districts of New England, which were lighted with beautiful white gas. On inquiring into the sources of supply, I found there was no gas in the ordinary sense, but that common air saturated with a light petroleum naphtha was being burned. A tank containing the latter was buried in the garden, while a small machine in the basement of the house, worked by falling weights, drove common air through this tank. The air, saturated with naphtha, returned from the garden to the house and burned in every room exactly like gas. Again, I stayed some weeks in a seaside watering-place called Nahant. The town, to all appearances, was well lighted with gas. And so it was, but the gas was manufactured at each lamp. A small holder of light petroleum dropped its contents on a heated disc which converted it into gas, and this was burned, and had all the appearance of ordinary gas illumination. In fact, it was only a few days before I left that I found out the absence of ordinary gas from the town, though I constantly passed the street lamps.

This adaptability of petroleum to give a pure white light is the cause of its singularly rapid diffusion in different countries. The prejudices of the people in India are rapidly giving way, so that the consumption of petroleum in our Indian possessions has been increasing about 200 per cent. annually. In China its consumption is also rapidly increasing. Of American petroleum alone India last year consumed 94,000 tons, Japan 56,000 tons, and China 82,000 tons. As American oil is thus penetrating so extensively and rapidly into the great Eastern, as well as into the European markets, it would appear to be beyond competition. Nevertheless, a formidable competition is arising in Russia. On the shores of the Caspian Sea there are vast deposits of petroleum, and these, though they have scarcely yet been opened, already amount to one-sixth of the American production. The old proverb says, "It is a far cry to Loch Awe," and it is a much farther cry to the shores of the Caspian Sea. But if the reader will look at the map he will see that a railway, just opened between Baku, on the Caspian, and Batoum, on the Black Sea, alters the geographical position exceedingly. Baku is the centre of the Russian petroleum industry. The oil-bearing strata stretch from Baku, past the island of Tcheliken, 300 miles across the Caspian, through the great steppes of Turkestan, until it is lost close to the Himalayas. The bottom of the Caspian must contain much oil, for naphtha springs occur in that sea, and may be lighted by throwing a match upon the water, where oil is seen floating. Baku is situated on the Apsheron peninsula, with an area of 1,200 square miles, throughout which there are oil-bearing strata; but as yet only three square miles have been worked. The accounts of this district given by O'Donovan in his wonderful ride to Merv, by Mr. Marvin, Colonel Stewart, Mr. Arthur Arnold, and others, have made the district familiar to us. Without putting too much stress on their singular descriptions of fountains of petroleum 300 feet high, wasting themselves

into petroleum lakes, it is sufficient to know that there are 400 wells of oil in the small explored area. Around it the hamlet of Baku has become a city of 30,000 inhabitants. The price of petroleum at these wells is less than that of water. The crude oil has been selling at 4d. per barrel of forty gallons. Still all this resource of petroleum is worth little if it cannot be purified cheaply and be transported economically. This difficulty has been solved by the ability and energy of Mr. Ludwig Nobel, a practical engineer. He is of Swedish extraction, and has become the Russian oil king. Mr. Nobel has built steam fleets entirely for the quick transport of the finished oil, and these steamers are propelled by the refuse of the distillation. The refined oils pass by pipes to the end of a jetty, and are pumped directly into the holds. These ships, when they reach harbour, pump the petroleum into specially-constructed railway vans or reservoirs, twenty-five of which form a train When this arrives at its destination, the petroleum is again pumped out into distributing tanks, of which there are many of varying capacity throughout Russia. In this way American petroleum has been driven out of Russia, while Caucasian petroleum has taken its place. This would not affect the rest of Europe greatly, were it not that the Russian oil king is already pouring petroleum through the Baltic into Germany; and he is preparing to flood the Mediterranean and India through the Black Sea, by the railway connecting Baku with Batoum, or, to speak more generally, the Caspian with the Black Sea. If these ventures have a commercial success, there is, undoubtedly, petroleum in the Caucasian lands sufficient to supply the world with that commodity for a prolonged period of its history. Already, in different parts of Russia, both steamboats and railway locomotives are driven by burning the waste of petroleum under the boilers. It will certainly be a marvel, but one which may be before long realised, to see a petroleum fleet laden at Batoum with

Caucasian oil, pass through the Suez Canal without the aid of coal. This would be an immense gain to the stokers, who have a bad time in the Red Sea, one of the hottest parts of the world; for petroleum ships require no stoking to their fires. For myself, I should like to see such a Russian invasion of India through the Suez Canal in a peaceful, industrial competition. If a trade of this kind could be established with a good profit, a warlike invasion by the Himalayas would be an absurdity, for peaceful commerce with Russia would tend more to the security of our Indian Empire than all our diplomatic watchfulness in Central Asia.

Part III.

NATIONAL EDUCATION.

1. PRIMARY EDUCATION
2. TECHNICAL EDUCATION
3. TEACHING UNIVERSITIES AND EXAMINING BOARDS.
4. UNIVERSITIES AND PROFESSIONAL EDUCATION.

Part III.

NATIONAL EDUCATION.

ON PRIMARY EDUCATION.

This Presidential address was delivered at the meeting of the Social Science Association, in September, 1870.

FOR thirty years previous to 1870 efforts had been made to bring the State into proper relations with the education of the people; but they had been unsuccessful, on account of the conflicting interests and jealousies of religious bodies. The churches charged with the promotion of religious sentiment among the laity naturally thought that they should charge themselves with the education of the people, in order to advance their moral and religious welfare. But the want of union among churches led to a discordant action in the means employed, and though much was accomplished by voluntary zeal, still no common national system of education was evolved from these ecclesiastical cares. Hence, while other nations in Europe have spread primary and secondary education in well-organised systems throughout their lands, England had not even laid the foundation-stone of a national system till 1870. And so we had the disgrace of having the worst educated people, as a whole, of any country which professes a high civilisation. It is true that, since 1839, the State has made various attempts to found a national system; but they have been baffled by the

jealousies of religious bodies. Bill after Bill brought before Parliament has been sunk under the cross fire of sectarian artillery. Happily, the Act of 1870 resisted this antiquated firing, although it was freely enough opened on the Bill, as it sailed through the House.

I have said that the State began its connection with education in 1839 Then Parliament interested itself in the efforts of voluntary agencies to spread education among the people. It voted sums of money in aid, and sent inspectors to the schools to see that the money was properly applied; but that was the whole connection of the nation with elementary education. Where no voluntary efforts had been made in a district, the State left that unfortunate district alone, and its people continued in their ignorance. So it came to pass that rich, prosperous localities received education; while poor, miserable places, having no population fitted to make the preliminary voluntary sacrifices, got nothing at all. The rich were filled; but the poor were sent empty away. In no point of view could such a system be called national. Yet England was the only part of the United Kingdom which did not enjoy a national system. Scotland possessed one for nearly 200 years, and Ireland had one of more modern growth. It became, therefore, intolerable that England should remain in dependence on the efforts of religious bodies alone, without possessing a system that would, at all events, step in to do the work, when they, from inability or unwillingness, left the work undone.

At last Parliament passed a measure of national education for England and Wales. Whatever are its shortcomings, it has the great merit that the State has at last been brought into national relations with education. Government has been entrusted with powers both of initiation and control, while localities have been made responsible for the education of their inhabitants. It is the duty of localities,

either by voluntary efforts or public rates, to supply adequate school accommodation for the people, though Parliament holds the Government responsible for seeing that this great end is achieved. Three leading principles in the Act give it a national character. First, that it is the duty of localities to bring education within the reach of every child in England; secondly, that it is the duty of parents to make their children attend the schools thus provided; and, thirdly, that it is the duty of the Government to see that the objects of the Legislature are fulfilled. In giving powers to effect this triple obligation, the Act is sometimes vigorous, sometimes feeble, and has received various amendments to secure its efficient working. Yet with all its defects it is an enormous stride in advance, as it has substituted well-defined responsibilities for the past ignoble relations of the State to education. It was high time to impose them. Under the old system of mere contributory help, schools, indeed, multiplied, but education slipped backwards. The ages of school children were lowered year by year, and, as a necessary consequence, the amount of education had to be lessened. In our schools in 1870 there was now only about half the proportion of children between the ages of thirteen and fourteen that there was twenty years ago, and there was one-third fewer between the ages of ten and eleven. This was a melancholy outcome of State interference with education by the contributory method. The Revised Code rather accelerated the decadence. Its principle had much of vitality—individual examination and payment by results—but the examination led to mechanical teaching in the lower standards chiefly, while the results were scarcely worth paying for. And so the education of the country is in a truly melancholy state. The Act which made education national deals with the quantity of education, but not with its quality. [As regards quantity, Mr. Forster's Act has produced the

most satisfactory results. In 1870, when this address was delivered, there were only 8,281 inspected schools with 1,878,584 scholars taught by 28,000 teachers. In 1886 the schools had increased to 19,133, with 5,145,292 scholars taught by 87,000 teachers. In fact, these represent nearly the whole children of school age. The number of School Boards amounts to 2,225.] Still, the number of schools in a country is of small consequence as compared with the nature of the education given in them, just as the number of bottles in a cellar matters little if the wine be bad. Under these circumstances, bear with me in discussing the subject of quality in our schools, even if I appear in the light of the uncommonly candid friend whose indication of one's faults is generally not soothing.

In education, as in everything else, our position is not of our own making; for our experience, our conceptions, and our prejudices, have descended to us by inheritance. Accordingly, we find that our present system is very much of an ecclesiastical inheritance. It is needless to go so far back as the days of monasteries, when excellent schools were attached to them, often for the political purpose of raising the middle classes as allies to the Church in resisting the power and encroachment of the nobles. These were grand old schools, but they represented our Etons, Harrows, and Rugbys, rather than the elementary schools with which we are dealing. The latter are the growth of modern times, and were raised by Churches, which naturally thought that the chief preparation of man ought to be for the future, and that the school, like the Church, was intended for his eternal, not for his temporal condition. Some duties, with regard to the latter, it was important to inculcate—humility, obedience; give unto Cæsar the things that are Cæsar's; pay your taxes, and above all things your tithes; touch your hat to the parson, the squire and his lady; for these, in a temporal sense, form the chief end of man. And so village schools

became things of small temporal use, but well fitted, as the old phrase went, to keep men satisfied with the sphere in which they were born. The old parish aspiration of a school used to be—

> "God bless the Squire and his relations,
> And keep us in our proper stations."

Gradually the Church was emancipating itself from these narrow views, and was developing the village schools into broader and more useful institutions. The State has thrown them back to their pristine narrowness, and our schools are little more than mere mechanical manufactories, turning out no end of yards of the three R's, in standards one, two, three, and four, but very few of standards five, six, and seven, for the latter do not pay.

The original idea of the Church, if it could have given a fair amount of consideration to the temporal condition of man in comparison with his eternal state, was to educate him in correlation to his work and condition of life. The same idea is manifested whenever the State, in olden times, interested itself in education. The ancient laws of apprenticeship were in fact laws of education. Only the State reversed the process followed by the Church, and thought of man's temporal condition first, and of his eternal state afterwards. The State took up all vagrant boys, and sent them, by compulsion, to a farmer, blacksmith, or a shoemaker, first to follow the plough, to hammer iron, or make shoes as their chief end, and to learn the Ten Commandments as a supplement. Ability to labour and support yourself formed the main idea of education in olden times, when the State passed laws relating to it; and it must be owned this went to the root of the matter. The State had no idea that education was worth much, unless it fitted a man for his work in life. The first direct compulsory law relating to education in this kingdom, that I have met with in my studies, was

passed by James IV., of Scotland, in 1494. He ordained that all sons of freeholders and barons should go to school under penalty, and that their eldest sons, who were to have the estates, should, after their preliminary education, attend three years at a school of law, in order that they might administer, discreetly and wisely, justices' justice to the poor folk of the realm. It is a pity that this compulsory law does not still exist for eldest sons! You see in it the idea that education should be adapted to the work of life. This main idea of fitting a man for his work was vigorously supported by our old reformers. John Knox held firmly by it, especially in his scheme for secondary education, which, unfortunately for Scotland, was never adopted, though his plan for primary education was. In the former he announced that no boys should leave school till they had devoted a proper time to "that study which they intend chiefly to pursue for the profit of the commonwealth." This is the old conception of the object of education, and reappears at the present day under the modern garb of "Technical Education. All the reformers urged its necessity, especially Luther and Melanchthon. Most European States have held fast to the idea with more or less of development, but it has vanished utterly from our English schools. Goethe brings out the idea finely in the travels of Wilhelm Meister in the pedagogic province, where he left his boy for education. Every boy in that province was specially trained according to his aptitudes, in whatever direction these manifested themselves. Wilhelm Meister, after a twelve months' absence, revisits the province. He comes upon a cloud of dust produced by a troop of wild horses under a course of training by mounted boys. One of these was his son, for horse-breaking was made his main education, as he was found most fitted for it. To soften his mind under such a system, he was also carefully instructed in Italian literature. So was it with all the boys in this educational

province. Some were masons or carpenters, some artists or musicians, all being treated according to their main aptitudes, though each had a collateral study to supplement the mental deficiency which experience showed to arise in such a course of training. Every pupil in the pedagogic province learned reverence (*Ehrfurcht*), and that of three kinds—reverence for that above him, reverence for that around him, and reverence for that beneath him. In this quaint allegory of the pedagogic province, you will find the secret of the prosperity of Prussia, a State at the back of Europe, which only got its civilisation long after the Christian community of Europe had organised themselves. She has lately shown what education can achieve in the union and advancement of a people. Even in the least productive of arts—that of war—see how she is served by the universal education of the soldiers. In England, the conception of a soldier is that of a mere obedient tool in the hands of an officer; the Prussian conception is that a soldier should not only be obedient, but also self-intelligent. Trusting to this intelligence maps of the invaded districts are distributed among the privates, who have the main geographical features thoroughly explained to them, so that every private can co-operate intelligently with his general. In the Franco-German war we were startled to hear of large bodies of French soldiers being cut off by losing their way in their own country. No German losses from such ignorance, not even of Uhlan scouts, are recorded. In fact, two countries in these days are not fairly matched in war, whatever may be the personal valour of their inhabitants, when one like France has 28 per cent. of her soldiers unable to read and write, while the other, like Germany, has not 3 per cent. Knowledge is as important as valour in modern combats.

The educational principle of continental nations is to link on primary schools to secondary improvement schools.

The links are always composed of higher subjects, the three R's being, in all cases, the mere basis of instruction. Elementary science, and even some of its applications, is uniformly encouraged and generally enforced. I shall not detain you with examples, as they are to be found in any work treating of continental schools. But as we have no schools corresponding to the secondary improvement schools for the working classes, we suppose that we can do without the higher subjects used as links. With what result? Our primary schools, on the whole, do not teach higher instruction than a child of eight years of age may learn. In our class of life, our children acquire such knowledge as a beginning; with the working classes they get it as an end. What an equipment for the battle of life! No armour plate of knowledge is given to our future artisan, but a mere thin veneer of the three R's, so thin as to rub off completely in three or four years' wear and tear of life. I am speaking on official record, for we are assured by inspectors, that nothing under Standard IV. suffices for permanent use, and yet the Committee of Council tell us that four-fifths of the children of ages at which they leave school pass only in lower standards. Under new minutes, inducements have been given for subjects higher than the three R's, but for some reason they produce scarcely any result. At the present time, little more than three years, between the ages of six and ten, is the period devoted to the education of the working classes. Less than ten in the hundred attend four years at one school. What are we to do against such difficulties? How are we to economise precious time, so as to make the most of it, and how are we to induce parents to give us more time for the benefit of their children? Our ancestors appear to have had a greater educational power than we now possess, for John Knox tells us, in his First Book of Discipline, that two years "are more than sufficient for to learn to read perfectly, to answer the Catechism, and

to have entries in the first rudiments of grammar." Germany, with her trained staff of teachers, organised and recognised as a profession, gives three years for elementary instruction, such as is embraced in our Privy Council Standards; but in this country we do not succeed in accomplishing it. So, under our present system of elementary teaching, no knowledge whatever bearing on the life work of the people reaches them by State education. The air they breathe, the water they drink, the tools they use, the plants they grow, the mines they excavate, might all be made subjects of surpassing interest and importance to them during their whole life; and of these they learn not one fact, and yet we are surprised at the consequences of their ignorance. A thousand men perish yearly in our coal mines; but no schoolmaster tells the poor miner the nature of the explosive gas which scorches him, or of the after-damp which chokes him. Boilers of steam-engines blow up so continually that Committees of the House of Commons have been engaged in trying to diminish their alarming frequency, but the poor stokers, who are scalded to death or blown to pieces, were never instructed in the nature and properties of steam. In Great Britain alone more than 100,000 people perish annually, and at least five times as many sicken grievously, out of pure ignorance of the laws of health, which are never imparted to them at school; and they have no chance of learning them afterwards, as they possess no secondary schools. The mere tools of education are put into the hands of children during their school time without any effort being made to teach them how to use the tools for any profitable purpose whatever; so they get rusty or are thrown aside altogether. And we fancy that we have educated the people! Our pauperism, our crime, and the misery which hovers on the brink of both, are very heavy, and our panacea for their cure is teaching the three R's up to Standard IV. or V. The age of miracles has

passed by, and our large faith in our little doings will not remove mountains. It is best to be frank. Our low quality of education is impoverishing the land. It is disgracefully behind the age in which we live, and of the civilisation of which we boast; and until we are convinced of that we cannot be roused to the exertions required for its amendment. This is no new complaint, and has been long ago made by far higher authorities than myself. On the 4th of May, 1835, Lord Brougham moved a resolution in the House of Lords in the following terms:—"That the kind of education given in the greater number of schools, now established for the poorer classes of the people, is of a kind by no means sufficient for their instruction, being, for the most part, confined to reading, writing, and a little arithmetic; whereas, at no greater expense, and in the same time, the children might easily be instructed in the elements of the more useful branches of knowledge, and thereby trained to sober, industrious, prudent, and virtuous habits."

In censuring the low condition of knowledge in our primary schools, as represented by the results of the Revised Code, I do not aim to restore them to the position which many of them had before it. That Code was, in fact, rendered necessary, because their aggregate teaching was not sufficiently large and diffused to justify the increasing expenditure. In imitation of our classical schools, verbalism and memory-cramming had grown up as tares, and choked the growth of the wheat. Words had taken the place of conceptions. A child could tell you about the geography of the wanderings of the children of Israel, but had no conception whatever of the ordinary phenomena around it. It was hopeless to put to him the commonest scientific questions. Whence comes the water that fills the Thames? What is the origin of hail, snow, rain, or dew? Why does the sun rise in the east, or set in the west? What produces night and day, summer and winter? In history scholars

could rattle out to you the names and dates of Kings and Queens, perhaps even the names and ages of all Queen Anne's children as they died in childhood; but, as to a true historical conception, apart from memory-cramming of words and dry facts, to be vomited forth upon the examiner, it required a very good school under the old system to find it. Words, instead of ideas, were worshipped. Inspectors, under the old system, did something to correct this tendency to verbalism and cram; under the new system they have no time, and, if they had, they would find fewer of the higher subjects taught in any way.

The teaching of science, if properly done, is the reverse of all this, and will go far to remedy its defects. I agree with my friend, Professor Huxley, that books in this case ought only to be accessories, not principals. The pupil must be brought in face of the facts through experiment and demonstration. He should pull the plant to pieces and see how it is constructed. He must vex the electric cylinder till it yields him its sparks. He must apply with his own hand the magnet to the needle. He must see water broken up into its constituent parts, and witness the violence with which its elements unite. Unless he is brought into actual contact with the facts, and taught to observe and bring them into relation with the science evolved from them, it were better that instruction in science should be left alone. For one of the first lessons he must learn from science is not to trust in authority, but to demand proof for each assertion. All this is true education, for it draws out faculties of observation, connects observed facts with the conceptions deduced from them in the course of ages, gives discipline and courage to thought, and teaches a knowledge of scientific method which will serve a lifetime. Nor can such education be begun too early. The whole yearnings of a child are for the natural phenomena around until they are smothered by the ignorance of the parent.

He is a young Linnæus roaming over the fields in search ot flowers. He is a young conchologist or mineralogist gathering shells or pebbles on the sea shore. He is an ornithologist and goes bird-nesting; an ichthyologist, and catches fish. Glorious education in nature, all this, if the teacher knew how to direct and utilise it. But as soon as the child comes into the school-room, all natural God-born instincts are to be crushed out of him; he is to be trained out of all natural sympathies and affections. You prune and trim, cramp and bind the young intellect, as gardeners in olden times did trees and shrubs, till they assumed monstrous and grotesque forms, altogether different from the wide-spreading foliage and clustering buds, which God himself gave to them, and which man is idiot enough to think he can improve. Do not suppose that I wish the primary school to be a lecture theatre for all or any of the "ologies." All the science which would be necessary to give a boy a taste of the principles involved in his calling, and an incitement to pursue them in his future life, might be given in illustration of other subjects. Instead of mere descriptive geography, drearily taught and drearily learned, you might make it illustrative of history, and illustrated by physical geography, which, in the hands of a real master, might be made to embrace most of what we desire to teach. The properties of air and water, illustrations of natural history, varieties of the human race, the properties of the atmosphere as a whole—its life-giving virtues when pure, and its death dealings when fouled by man's impurities—the natural products of different climes, these and such like teachings are what you could introduce with telling and useful effect. Far better this than overlading geography with dry details of sources and mouths of rivers, of isothermal lines, latitudes and longitudes, tracts of ocean currents, and other tendencies towards the old verbalism and memory-cramming. If I have explained myself with

clearness, you will see that while I advocate the introduction of higher subjects into our schools, I wish them to be of immediate interest and applicability to the working classes. The main difficulty in educating them is to get them to stay long enough at school. Teach them, while you have them, subjects of interest and utility. The short time will thus be made productive, and inducement will be offered for its extension. Six months spent in teaching future labourers the geography of the wanderings of the children of Israel is sheer waste of time, either for their eternal or temporal interests. Think of the few precious hours as the training for a whole lifetime, and let us use them by giving living and intelligent learning, not obsolete and parrot instruction. Those who are believers in the teaching of the great secondary schools of this country will deem my aspirations for the improvement of primary education low and utilitarian. Frankly I admit the latter. Such a style of education will never realise Lord Brougham's hope that the time may come when every working man in England will read Bacon; but it may contribute to the fulfilment of Cobbett's desire, that the time might come when every man in England could eat bacon. I deny, however, that the utilitarian view of primary education is ignoble. The present system is truly ignoble, for it sends the working man into the world in crass ignorance of everything that he is to do in it. The utilitarian system is noble, in so far as its treats him as an intelligent being, who ought to understand the nature of his occupation, and the principles involved in it. If you bring up a ploughman in utter ignorance of everything relating to the food of plants, of every mechanical principle of farm implements, of the weather to which he is exposed, of the sun that shines upon him and makes the plants to grow, of the rain which, while it drenches him, refreshes the crops around, surely that ignorance is not conducive to his functions as an intelligent being made after the image of Him who has done all things

wisely. Would not the ploughman feel a truer nobility in his education, and a more grateful feeling to God and man, if he had been taught to see in everything, even in the tree which shades his cottage, an illustration of infinite wisdom? To his uneducated vision, that tree is a mere thick piece of wood, with other smaller pieces sticking out of it, in as prosaic conception as the primrose was to Peter Bell in Wordsworth's poem. To his educated vision these branches would appear like arms stretching forth to heaven to pray for food, and he would see in what a wondrous manner that prayer was granted. From the transparent air around, aerial food is extracted and moulded into forms of organic life, while from the earth beneath comes the terrestrial food co-operating with the air in the process of nutrition. In all the operations of the field, from the breaking up and manuring of the soil to the harvesting of the grain, which of the two men would feel that he had the most noble education—the ignorant clodhopper knowing nothing that he is doing, the mere tool or slave of his master, as little advanced now as he was when described in the old book of Ecclesiasticus—or the worker, intelligent, and knowing his occupation, aiding nature to fulfil her wise laws, and by doing so feeling himself like St. Paul, and with his humility also, to be "a fellow-worker with God"! I have selected for illustration the occupation in which the working man is now the least cultured and intelligent, but there is not a single craft which could not be dignified in a similar way.

In the original minute of 1839, the Committee of Council pledged themselves to connect the subject matters of education with the occupation of the people. The words of the minute are:—"To give such a character to the matters of instruction in the school as to keep it in close relation with the condition of workmen and servants." This refers to a normal school which was to be an example to all others, but the precept and the practice have alike been forgotten

Let me refer you to an example, scarcely known, as it is separated from us by stormy seas, though it is singularly instructive and significant. You will find it fully described in Mr. Tuffnell's Report on the Employment of Men and Women in Agriculture. Those of us who have passed middle life recollect the chronic state of misery and poverty which used to exist in the Scilly Islands, off the coast of Cornwall. In such a wretched condition were they, that the inhabitants were only preserved from starvation, during the winter months, by constant contributions from the mainland. Now, we never hear cries of distress from these islands, and for what reason? In 1834, Mr. Smith, who became their lessee, undertook their improvement. He abolished the cottar system, consolidated holdings, founded good schools under a compulsory system of his own, and kept them up to the mark by constant inspection. He did not content himself with the three R's, but directed the instruction towards the occupations of an insular people. History, geography, the rudiments of mathematics, and navigation were taught to the children. And with what result? So much esteemed are the youths of the Scilly Islands as sailors, that vessels sometimes stop there to procure them, and frequently they rise to be mates and masters. Pauperism has vanished from the islands, so that it is difficult to find any of its population poor enough to accept the alms offered in the Communion Service. The well-educated population show a disposition to pass to the mainland, for they are much appreciated there, and receive high wages. All this is as it should be, and Mr. Smith deserves our thanks for having preserved to us an example of what the Government intended to do, but failed to accomplish, viz., to direct the subject matter of education to the occupations of the people.

The great advantage of directing education towards the pursuits and occupations of the people, instead of wasting it on dismal verbalism, is that, while it elevates the individual

it at the same time gives security for the future prosperity of the nation. In the industrial battles of people, we are content to leave our working classes armed with the old Brown Bess of warfare, while men of other countries are arming themselves with modern weapons of precision. In the competition of nations, the two factors of industry—raw material and intellect applied to its conversion into utilities —are altering their values. The first is rapidly decreasing, the second quickly augmenting in value. We anchor our hopes on the sand, which the advancing tide of knowledge is washing away, while other nations throw out their anchors on firm ground accumulating around, and enable their vessels to ride in safety. There are instances of nations, rich in the natural resources of industry, yet poor from want of knowledge to apply them; and there are opposite examples of nations utterly devoid of industrial advantages, but constituted of an educated people, who use their science as a compensation for their lack of raw material. Spain is an example of the first class, and Holland of the second. Spain, indeed, is wonderfully instructive, and her story is well told by Buckle, for you see her rise in glory or fall in shame, just as there are conditions of intellectual activity or torpor among her inhabitants. Sometimes animated with life, Spain seeks a high position among nations; at other times she is in a death-like torpor. She is an apt illustration of that sentence—"He that wandereth out of the way of understanding, shall remain in the congregation of the dead." During the period of the Inquisition education was only allowed so far as it did not interfere with ecclesiastical fears, and the country fell into a state of abject misery and dejection. The Duke of St. Simon, then French Ambassador at Madrid, declared that "science in Spain is a crime, and ignorance a virtue." During the next century, there was a period of three generations when foreign science and

experience were imported by the Spanish kings, and the country began to rise again to some condition of education and prosperity. In the last half century it has relapsed, ecclesiastical power having again assumed its old sway, and Spain has returned to a position of obscurity, from which, let us hope, she may emerge by her late revolution. For this nation has everything in the richest profusion to make it great and prosperous. Washed both by the Atlantic and the Mediterranean, with noble harbours, she might command an extensive commerce both with Europe and America. Few countries have such riches in the natural resources of industry. A rich soil and almost tropical luxuriance of vegetation might make her a great food-exporting nation. Iron and coal, copper, quicksilver, and lead abound in profusion, but these do not create industries, unless the people possess knowledge to apply them. When that knowledge prevailed, Spain was, indeed, among the most advanced of industrial nations. Not only her metallurgic industries, but her cotton, woollen, and silk manufactures were unequalled; her shipbuilding also was the admiration of other nations. All have decayed because science withers among an uneducated people, and without science nations cannot thrive. Turn to Holland, once a mere province of Spain. She has nothing but a maritime position to give her any natural advantage. Not so bad, indeed, as Voltaire's statement that she is a land formed from the sand brought up on the sounding-leads of English sailors, though she is actually created from the *débris* of Swiss and German mountains brought down by the Rhine. Hence within her lands are no sources of mineral wealth; but she has compensated for its absence by an admirable education of her people. For my own country I have no ambition higher than to get schools approaching in excellence to those of Holland. And so this mud-produced country, fenced round by dykes to prevent the ocean sweeping it away, is thriving, prosperous,

and happy, while her old mistress—Spain—is degraded and miserable.

Let me here interpolate some remarks on physical education, for events around us press it upon our attention. In the first minute of the Committee of Council, dated April 13, 1839, the following passage relating to it is to be found:—"Besides the physical training of the children in various employments, such exercises are to be introduced during the hours of recreation as will develop their strength and activity." Wise words these, but wholly forgotten in practice, except in a few Union Schools. Yet physical training of the young is a subject of national importance, scarcely less weighty than their intellectual training. I need not remind you of the importance which Greece and Rome attached to it. Greece had an exercise ground in every city, and Rome had its Campus Martius. No doubt the main reason for its encouragement was to preserve the martial spirit and physical powers of the people. The militia of the Greek and Roman Republics was of such moment to them, that an exaggerated value of physical training arose. Prizes in the Olympic, Isthmian, or Nemean games, made not only the winners but their kinsmen illustrious. Modern events have been bringing back nations to these ancient customs. Separate standing armies, selected from, but not backed by the body of the people, are less in favour than they were. A splendid standing army of Prussia, though admirably equipped and drilled, was vanquished in four weeks by the great Napoleon in 1806. In the same number of weeks in the late war a French standing army, under another Napoleon, was crumpled up by a German militia under the King of Prussia. Three years' service in the line and a national militia make every able-bodied Prussian a soldier. In Prussia and Switzerland, where militias are now more important than standing armies, an increasing value is attached

to gymnastic training in their schools. Efficient school instruction, with good physical training, shortens by a year a man's military service in some of the German States. This is wise and easy to be understood. When military drill is thrown into schools, as in the Hibernian Academy, the Chelsea School, some of the Union Schools, and the Middle-class Corporation Schools in London, an important national result is secured, for the scholars are habituated, at the most plastic period of their life, to soldierly obedience and exercises which will induce them, even when they go into trades and occupations, to join the volunteer or militia services of the country. You thus throw back the acquisition of military training to a non-productive age, and thus economise the labours of the people. No nation can afford to neglect her defensive resources. If you can actually develop these in a way which, far from crippling, increases the industrial resources, it is no small matter. Any one who has seen the children in well-drilled Union Schools will understand what I mean. A class of ill-fed, stunted children, brought up in badly-ventilated, dirty localities, come into those schools under the most unfavourable conditions for success. Under the half-time system, with drill and gymnastic exercises, this unpromising raw material is fashioned into productive utilities anxiously sought for in the labour market. Their physical condition becomes rapidly improved, their intellectual capacities brightened, and their habits of working together in strict obedience make them valuable labourers. Schools, with children in a less depressed condition would give still better results; though, even in such Union Schools, only about 3 per cent., instead of the old 50 or 60 per cent., are returned as unprofitable servants. I wonder whether Eton or Harrow yields a smaller percentage of useless lads. In them athletic games are also practised, though less systematically, and with perhaps an excessive zeal, resulting as a

reaction from the unutilitarian nature of the studies. A population, like that of this country, having a disposition to gather in cities in order to work in factories, must necessarily degenerate in physical power. The excessive mortality is a proof of this. This degeneracy may be much counteracted by good courses of physical training in schools. A better and more productive class of labour would thus be assured, while the nerve, sinew, and pluck of the people would be preserved as a store for emergencies which may happen in the life of any nation. School drill in military and naval exercises, besides their educational value in discipline and united action, sow the seed of national strength in an economical way. Nearly 20,000 children die each year of filth and foul air diseases in England and Wales, and far more have their vitality lowered by such influences. The Greek and Roman Republics may have exaggerated the importance of physical training, but we have certainly depreciated it unwisely. When we see Germany, Holland, Switzerland, and France making it a part of school life, we had better take the matter into our serious thoughts.

I now pass to compulsory education. An improved quality of education is a necessity for its enforced reception by the people. The logic of circumstances drove Parliament into the recognition of compulsion ; and the same logic will oblige the Legislature to make it efficient. Let us look at the facts which compelled the recognition of the principle. The right of suffrage has for its corollary the duty of instruction. You cannot give political power to a people and allow them to remain ignorant. That would be the political suicide of a nation. The people, in all their grades, are surrounded and imbued with the prejudices acquired in their upbringing, either from their parents or those around them. An uneducated people are like a nation one or two generations back in its history. They cannot grasp the ideas of the age in which they live, and are powerless to

shake themselves free from the prejudices which the progress of thought has proved to be dangerous errors. They are unable to do so, as they cannot take possession of the inheritance of intellectual wealth accumulated by their predecessors; for they do not know how to read the books forming the testament by which it was bequeathed. An uneducated people, endowed with political power, is, therefore, an anomaly, in the highest degree dangerous to a nation. Hence, when we bestowed the suffrage on the people, it became necessary that they should have efficient instruction as its corollary. Secondly, we have now established what every civilised nation except England has long had—education by local rates. A civic support of education has again for its corollary enforced instruction of the individual citizen. For if it be right that the State should compel a community to educate all its citizens, it must be right to give power to that community to extend the education to every citizen. You cannot enforce education unless you make it of a quality which you are certain will be useful to the person receiving it. To compel every boy and girl to continue at school until thirteen years of age, involves the necessity that the instruction should aim at something more than a boy of eight may readily learn. Yet, as an aggregate result, that is all our elementary schools do at present. Compulsory education, then, involves an improvement in its amount and quality. It would be an unredeemed hardship to compel children to attend schools unless these were made suitable to their wants in life. Compulsion is of two kinds, direct and indirect. By the direct method every parent is bound to keep his children at school, or be punished for the neglect. The indirect compulsion means that education shall be made the first tool with which labour can be begun, and if that tool be not in the possession of the candidate for employment, the employer must not engage him. The indirect plan has the high authority of Adam

Smith in its favour, but it is unnecessary to indicate a preference between the two methods, for both may be good and necessary. Direct compulsion is most easily applied when it is least required, that is when public feeling is entirely in its favour, and denounces the parent who neglects the education of his child as just as much a brute as if he starved it by refusing bread. In England you have about half a million of these brutes to deal with, and their commonness prevents an adequate public censure of the magnitude of their crime against society. The two difficulties we have to contend with, in applying a compulsory law to neglected children, are the following:—Firstly, the ignorance and lethargy of parents; and secondly, the demands of the labour market for a supply of juvenile workers. The children form part of the productive powers of the family circle, and their wages are required for its support. Even when the daughters are not in receipt of wages, they are handmaids at home, and enable the father, mother, and boys to earn wages. This being so, how are you to reconcile education with these demands? Unless you can devise some method of making the parents allies of the State, compulsory laws will be vain. In this country all laws require the co-operation of those for whose benefits they are framed. While there is nothing in direct compulsion to induce parental co-operation, there is much in the indirect plan to do so. If the law firmly ruled that employers shall not give work to inefficiently educated children, every motive of the parent is enlisted for their education. The prudent, loving parent will always be an ally of the State; but the sordid, selfish parent will be so also, when the education becomes the only tool through the possession of which wages can be earned. Even in States which have had direct compulsion for a century, the system of indirect compulsion is being enacted as a supplement and support to the former. The Act of 1870 was based on direct

compulsion, but it has since been supplemented by the indirect compulsion of the Factory Acts, although it was left to localities to determine their own standards of exemption, some being as low as Standard II., while others took Standards IV. and V. In foreign countries no children are discharged from education at such low standards, but they must continue it at improvement schools up to the age of sixteen, and generally they must acquire a foreign language as part of their training.

Graded education is one of the subjects which the section, over which I have the honour to preside, is asked to consider; and I must not pass it over in silence, even though it is too large a subject to be treated among so many others in this address. No doubt it is one of the most important questions of education before this country. In England the University is at one end of the chain and the elementary school at the other, but so far apart that it seems hopeless to bring them together. It is not so everywhere. In Scotland the national universities and the parochial schools are in intimate union. It was once so also in England when the Universities of Oxford and Cambridge were the great upper schools of the kingdom, attended by many thousands, not only from England, but from Scotland and Ireland also. Poverty was no bar to their attendance, for they begged their way or lived at friendly monasteries. Chaucer refers to the poor scholars who could only return prayers for gifts :—

> "Busily 'gan for the souls to pray
> Of them that gave him wherewith to scolay."

Bishop Latimer, in one of his sermons, alludes to the ease with which yeomen attended the universities in his early days, though he mourns the decay of the custom. The Scotch and German Universities accept the discipline of poverty as a part of education. You could not possibly

believe that a man like Heyne, who, while editing "Tibullus," had to gather peas-cod shells in the streets to boil for his dinner, and whose pillow consisted of two quartos, could have been educated at an English University. But in Scotland the poverty of the student would not have been remarkable, though his scholarship would. It is believed that about 500 working men, or sons of working men, are in attendance at Scotch Universities. Many that I have personally known have worked hard during the summer as ploughmen, fishermen, masons, carpenters—in one or two cases which I happen to know as gillies to young English University students during grouse shooting—in order that they might save enough to pay their moderate fees, and live on porridge and milk during the winter sessions of the universities. The parochial schools, from which they come direct to the university, have prepared and given them ambition for the work. Greek and Latin, mathematics, French, German, history, in addition to elementary subjects, are taught in these schools, not to all, but to those who desire them, and the son of the minister, the doctor, and the tradesman, sit on the same bench with the son of the ploughman. I have just left a Scotch town in which I was at a parochial school, and many a friendly grip of the hand did I get from working men and tradesmen who were schoolfellows with me. Neither of us had lost our respect for the other in our different careers in life, and it was a very hearty thing to feel that your old schoolfellows had an honest word of congratulation, if you happened to be in a more conspicuous position than themselves.

I have alluded to this mixture of classes in Scotch schools, in the hope of seeing it arise in England as a consequence of rate-supported schools. Every contributory ratepayer has a right to their use. Englishmen are sometimes astonished how Scotchmen get on in the world, but the

whole secret of it is that every Scotchman knows it to be his own fault if he is not educated. Since the time of the early Reformers this has been the case. Every presbytery had the pious duty imposed upon it of sending up lads "of pregnant parts" to the nearest university at the cost of the Church. This practice is no longer obligatory, though the numerous small bursaries or scholarships keep up the old habit still. It is quite true that the intimate connection of the people with the universities prevents the latter aiming at high scholarship; still, in metaphysics, science, medicine and law, they stand well in comparison with the English Universities. The poverty of a Scotch school renders a poet like Byron an impossible conception, but it makes natural one like Burns. I would not have alluded to our Scotch experience in regard to higher education for the poor, except as an encouragement for the English poor to follow up the paths opened up to them by the Endowed Schools Act. The enormous wealth of England, often wasted in restricted endowments, will, if well applied, open up ways of secondary education to the talented poor, such as the poorer northern division of the kingdom never had or can hope to have. The interval between the primary and the endowed school must be bridged over, otherwise the poor cannot pass. Standards III. and IV. of the primary school are far too narrow and weak structures to connect two educational systems. Hence it is likely that the talented poor will be defrauded of the inheritance devised for them by the Endowed Schools Act; and that the schools will be again appropriated as formerly by the middle and upper classes of society. The only mode of preventing this is to improve the quality of instruction in the lower schools. The higher subjects of a primary school need not be taught to all, though all should feel it to be in their power to seize hold of the instruction offered. In Scotch schools, from 5 to 7 per cent. of the scholars go on to higher subjects,

forming the intellectual fund of the country; and no nation has ever too large an amount of that. Perhaps the English Universities may yet, in the progress of reform, open portals of entrance to the talented poor, but the outlook is distant. The Endowed Schools Commissioners have recently shown an enlightened desire to improve the condition of schools for which new schemes are framed, though they have to battle against the ignorant prejudices of localities, and sometimes against representative ignorance in the House of Commons. These schools are not inspected, and the public remain in ignorance of the results of the revised schemes.

All nations which have in recent years revised their educational systems have provided a class of secondary schools for the industrial classes, specially devoted to teach them the principles of science and art relating to their industries. Holland compels every town of 10,000 inhabitants to erect such schools. Switzerland has her improvement and technical schools in profusion. So has France, Prussia, Austria, and other countries. Our endowed schools will not supply this want, hence we must look for them in another direction. Casting my eyes over the educational barrenness of our land, they fall upon a class of schools which might be converted to such a purpose. I allude to our half-time factory schools. At present they are nothing but primary schools. When compulsory education is fully at work, these factory schools might be made of material advantage both to the employer and the employed, if they were converted into useful secondary schools to teach the principles of science and art relating to the actual industries of the half-timers. The evening schools recognised by the Education Department are falling off in the numbers of their pupils. This is natural, because primary education is now compulsory in day schools. They would revive if they were converted into improvement schools for pupils of advanced age, especially if their

instruction were directed into the form of technical training of the industries of the localities in which they are situated.

It will be a relief to you to know that I have now reached the last division of my subject, though it is one which I cannot pass over in silence, for it forms the kernel of the whole matter. I allude to the position and qualifications of teachers in our primary schools. Any one who has experience in education will agree with the common saying, "As is the teacher, so is the school." The Rev. Canon Moseley, who has done eminent service to education, and was at one time a school-inspector, says, "As I go from school to school, I perceive in each a distinctive character, which is that of the master; I look at the school and the man, and there is no mistaking the resemblance. His idiosyncrasy has passed upon it. I seem to see him reflected in the faces of the children, as in so many fragments of a broken mirror." Ever since 1846 the Government have watched the training of teachers with care, and have taken securities that they should possess character, learning, teaching method and teaching aptitude. They have been chosen from the working classes in order to enlist their sympathies and to preserve for them an identity of interests. The school itself has been made the scene of a five years' training, and to this has been added two years of a collegiate life. Then provided with certificates of competency and trained fitness, and having given seven years' security of character, they are spread over the country to carry on their work of civilisation. In following this course we have only imitated the example of all States in which elementary education has been productive of public weal. In fact, it is the universal experience of nations, that however vigorous may be the central administration, however active the local management, and however lavish the public expenditure, the success and civilising powers of education depend wholly on the character, position, and attainments

of the teacher. If our training schools produce teachers who are fitted to discourage mere verbalism and cram, and if the Code were framed so as to encourage useful and higher subjects of education, we might have confidence in the present system. In Scotland the training of teachers is partly confided to the universities, and recently efficient colleges of a like character have been founded in the chief provincial towns of England. These might, with great advantage, be coordinated with our present limited system of training teachers. As long as Government instruction and aid are limited to the three R's of the Revised Code, it is a matter of little consequence. I see no justification for a high class of teachers, or for a high class of Government inspectors on such a system; and if it be continued, the country is likely to make a clean sweep of both. To have trained teachers and university-bred inspectors to teach and to test the mechanical system of the three R's, is like using Nasmyth's steam hammer, which can forge a beam, to crack an egg-shell. In the view which I have laid before you, the money of the nation is wasted in producing such results and no other. They are doubtless an excellent foundation for a superstructure, but what is the use of an expensive foundation if you never build the superstructure? I, who attach the very highest value to trained and certificated masters, feel that I am unable to defend either them, or inspectors of culture, on the present system; so what arguments will those who believe them to be unnecessary have for their abolition? Petty results are to be paid for; and these can be manufactured and appraised by a much cheaper staff than we have at present. My idea of results is not encircled by the three R's. The results tq be desired are the formation of character of the people, the moral and intellectual development of the rising generation, and their preparation for the battle of life. The discipline, the high tone, and the moral atmosphere of the school, requisite to

attain such results, find no place in the standards of the Revised Code. It is for these higher results that trained teachers and a cultured class of inspectors are necessary. Unquestionably the teachers trained for such purposes form a protected class, and protection is an unpopular word; but it is in no other sense than as the public has protection from ignorant quacks, in the shape of unqualified medical practitioners, or lawyers, or clergy. It is a protection of the poor against ignorance, and a protection of the State from the inroads of barbarism. No more important object lies before the Education Department in the future than the efficient organisation of the scholastic profession as a whole, so that it may become an object of ambition to the best youth of the country, and may afford to them adequate remuneration in their years of working vigour, with the power of providing for their old age. This would be a true economy to the nation, for a country which has sufficiently large resources in schools and teachers, possesses the elements of continued prosperity, and has little to fear in the advancing competition of the world.

I have now done. This year is memorable because, for the first period in our history, the State has been brought into national relation with education, and has accepted large responsibilities. If you believe that this Act has settled the scheme of national education, even for a few years, I trust that you are much mistaken. It has just touched the outskirts of the subject. The great object before us is to establish an efficient organisation of public intellect. Now, the national relations to it are in a state of chaotic confusion. There is the Committee of Council with two departments running side by side on parallel rails, yet never touching each other•lest disagreeable collisions might result. The Elementary School Department will have no aid from the Science and Art Department; and yet both are under the same masters—the President and Vice-President of the

Council. Again you have a third body, the Endowed School Commissioners, tacked on to the same Committee by a loose sort of thread, but not bound to co-operate with either department. Then you have all sorts of Government schools outside the Education Department altogether. Union and workhouse schools under the Poor Law Board; military and regimental schools under the War Office; naval and ship schools under the Admiralty; factory and industrial schools under the Home Office. Some of the universities receive large sums from Parliament, but are responsible to no public department for their proper use. In fact, we have educational materials in abundance, but no architect to make a national edifice out of them. We have not even decided which of them should be selected for the building of the future. Brick, stone, wood, iron are all useful in building; any one will do, yet all united would answer the purpose better. We quarrel among ourselves as to which should be used, so a substantial building is not even begun, and our castle is in the air. Humanists, realists, religionists, and secularists contend for their separate views, and refuse to co-ordinate them for the public good. In this confusion the public call for a Minister of Education, in the hope that he may be a nucleus round which the various educational materials may crystallise in a definite form. In the competition of nations, both in war and in peace, their position for the future will depend upon the education of their peoples. Local advantages or practical aptitudes may give them pre-eminence to day, but, unless supported by knowledge, that will vanish to-morrow. The competition of the future will be one of public intellect. The national system of primary education which I have criticised is our first effort to elicit order from disorder. It is the mere beginning of a mighty work, which this country must perform, if she is to escape the sentence passed on the Church of Sardis—"Thou hast a name that thou livest and art dead."

TECHNICAL EDUCATION.

This address was delivered to the Philosophical Institution in Edinburgh in 1870.

TECHNICAL Education means that those who are engaged in industry should have a trained intelligence and understanding of the special industries which they enter as bread-winners. In one sense it should begin in the Kindergarten and end at the College, for its great object is to train the faculties so as to teach working men how to observe, to appreciate, and to think. The primary schools of this country do not take the proper part in this system of education. The eye, the ear, the hand should be exercised in them much more than at present; the body should be kept in health by physical exercise; mere verbalism and useless knowledge should be discouraged. These defects in public elementary schools might be remedied by a more extended use of drawing, by the use of tools, by popular scientific lectures, and by arithmetic being taught more practically and less abstractedly. In other words, our schools should be made less bookish and more objective.

I do not intend to argue this question on the panic cry that this country is losing her position among manufacturing nations. I believe this cry to be true, and that the industrial supremacy of England is endangered for lack of knowledge, in spite of the practical aptitudes of her people. I prefer to rest the argument on general principles, which will convince your understanding that the immense attention bestowed upon the scientific and artistic education of the

people in foreign States arises from a necessity of modern civilisation, and must be followed by this kingdom. The question does not involve any suppression of classical systems of education for scholars who desire to follow them. In France, Germany, Switzerland, and other countries, which are moving so earnestly to promote the technical education of the industrial classes, the *lycées* and gymnasia are, to say the least, as numerous and good as our corresponding classical schools. The difference is that a much greater portion of the population has been induced to cultivate a higher education than formerly, because the idea has been abandoned that one kind of education is suitable to all schools, and colleges have been erected to teach the principles involved in occupations, the very names of which were unknown to Herodotus and Pliny.

In the early history of nations, the possession of raw materials or of local advantages determined their industries. Calicut, for a time, had an advantage over the rest of the world on account of her indigenous cotton. Under Abderrahman III. cotton was introduced into Spain, and the most notable improvements were made by Arabs and Spaniards in its manufactured products. Instead of painting calico by hand, the former invented the system of printing by blocks, and the latter invented cotton paper. In process of time, the cotton manufacture migrated from Hindustan, Arabia, and Spain, and settled in this country, far distant as it is from the source of the raw material. Why was this? Because, gradually though certainly, the value of the raw material as a factor in industry became less and less, while the value of the second factor—the skill and intelligence applied to it—became greater and greater. Note that the increasing factor was not mere human labour, for that is still cheaper in the countries from which the manufacture has departed than it is in

England. That is to say, it was not the brute labour of men, but the intelligent labour of artisans, either in possession of intelligence themselves, or reflecting the skill and science of their employers. No nation continues in the full enjoyment of a high state of national life unless the conditions of its existence remain the same, or unless it possesses sufficient elasticity to adapt itself to new conditions. Permanence of existence demands immutability of, or adaptability to, the surrounding conditions. This is the law of animated beings, as it is the law of nations. At one time the islands in which we live were inhabited by gigantic saurian reptiles, whose exuviæ we still use to fertilise our fields. They have passed away, or at the best are represented by degenerate types. Even among the lower creatures of the sea, living in conditions of greater permanence, and who have persisted through various geological periods to the present day, we see many changes, some of degeneracy, some of development. The recent dredging expedition found certain creatures, which are fully developed about the coasts of Arran, dwindled into dwarfed varieties, from having been drifted out of their favourable feeding grounds to other parts not so suited for their growth. This law of individuals is also the law of nations. Countries high in industrial position, like Greece and Arabia, have degenerated, because nations cannot be stationary, and they did not, or could not, adapt themselves to the changing conditions around them. Nations, like animals, have their changing struggles for existence. To remain prosperous they must possess the conditions which Herbert Spencer prescribes for individual welfare—"A constant progress towards a higher degree of skill, intelligence, and self-regulation—a better co-ordination of actions—a more complete life."

As the world progresses the conceptions of the head relieve the labour of the hands. In olden times women

and oxen did the brute labours of the household. Women ground the corn, till science taught mankind how to use the natural powers of water to turn mills. In modern times the puffing, panting engine represents the old brute labour employed in the early stages of manufacturing industry. We saw this illustrated, when 18,000 forced labourers on the Suez Canal were suddenly withdrawn, and their brute force was substituted by steam-engines, which did the work with greater efficiency and economy. In the progress of manufactures fewer labourers are employed, but they are paid higher wages, because their skill and the product of their labour is greater and cheaper. The cost of labour in the product of a machine factory is a decreasing quantity; it was 25 per cent. in 1840, 23 in 1850, 21 in 1860, 18 in 1870, 17½ in 1880. In cotton factories the brute strength of the man has been substituted by the quick fingers and eyesight of women and children, while the man's educated intelligence is employed instead of his physical force. The growth of the factory system changed our civilisation. With the rapid production due to steam power, the wares could no longer be sold by packmen carrying them on their backs for distribution throughout the country, so these human beasts of burden were thrust aside by the railway train. Let me illustrate this by the progress of the coal trade, especially as coal itself is the source of most of our mechanical power. When coal was originally got from the mine, miners mined the coal at the bottom of the shaft, then it was brought up in a basket by the men carrying it up ladders on their backs to the surface. After that, other bodies of men took it from them and they carried it down to the sea-coast, each man having a basket of coal on his back. A man could carry in this way a half-hundredweight of coal to the coast. After a little while a horse was brought in—the hay and oats were cheaper than the food of man. They put the coal on a pack-horse, which took three hundred-

weight, so that was more economical. After a little while someone thought of putting it in a cart dragged by a horse. That was done, and the weight was increased from three to sixteen hundredweight by the new application of the horse and cart. After that came the tram-line, which was laid down from the mine to the sea-shore, and a horse and wagon drawn over the lines carried forty instead of sixteen hundredweight. Then came the iron horse, eating coal and drinking water, and snorting steam out of its mouth as it went along, and this instead of forty hundred-weight carried forty tons. So they would see that coal, the source of power, gradually used its own force in cheaper and more economical ways until the labour of the human beasts of burden, who were only using brute animal force in the most degrading and wasteful way, was pushed aside, and the steam-engine did the labour and left the man to superintend it with his skill and intelligence. These displacements of labour are universal. Mechanical forces are displacing brute animal power, and the working men are gradually being converted more and more into intellectual workmen, who could exercise the thought, skill, and intelligence which they had never been able to get from or give to machinery. No wonder that, with this rapid change of conditions, loud cries of distress came from uneducated labourers who knew nothing except their acquired handicraft. No wonder that even now astonishment and consternation exist among like labourers, who see industries failing, and yet hope to preserve them by protective laws. They will as little affect the progress of intellectual industry as the Inquisition affected the revolution of the earth, though it burnt Bruno and imprisoned Galileo. Now if it be true that intelligent labour is continually supplementing brute labour, it must be equally true that no nation can remain in a condition of permanent prosperity, that does not give to its population as full an intelligence and as high an intellectual life as

all other competing nations. This thought made Michel Chevalier recently say, in speaking of the great technical school at Paris, "If the *École Centrale des Arts et Manufactures* were not in existence, it would be necessary to create it as the complement of the treaties of commerce." It is this conviction, shadowily conceived, and even yet imperfectly expressed, which makes the provincial colleges slowly abandon their imitation of old university methods by adapting themselves to the wants of their own localities. The managers have not even yet emancipated themselves from these old traditions, though the wants of the population are gradually carrying them into the conviction that Pope's maxim is a wise one, when he counsels us to "consult the genius of the place in all." It is a similar conviction that has induced my own University of Edinburgh to grant degrees in science,* engineering and agriculture.

We may take another illustration of our general principle from the art of war. The old Trojan and Grecian heroes did everything to develop their physical powers, for their combats and battles were chiefly won by endurance and strength. Sometimes, indeed, Pallas, the goddess of wisdom, punished them for prizing too exclusively their physical force, as when she tripped Ajax in his race with the wise Ulysses, who had prayed to her for aid; while the former, relying on brute force alone, was left grovelling in the offal of the lowing kine. Now war is a game of science and skill, not of mere material strength and valour. Our ships

* The degrees in science, which some of our universities think are unwise and a modern innovation, were, in point of fact, recognised by our ancestors. In the organisation of the Scottish universities after the Reformation, such degrees were distinctly referred to. In St. Andrews, one of the three colleges was to devote itself to teaching dialectics, mathematics, including arithmetic and geometry, cosmography, astronomy, and natural philosophy. The student who attended this course for three years and passed a successful examination "shall be laureat and graduat in philosophy."

of war, with their heavily-clad armour-plates, will have to dispense with them, as our knights of old had to do with their armour when gunpowder was invented. Great speed in cruisers will soon render useless our lumbering ironclads. The charges of our infantry and cavalry, with bayonets and swords, please women at reviews, but are rapidly becoming traditions of the past. Before long they will be as innocent weapons in wars of the future as are the halberds of those formidable beef-eaters who protect the Queen's palace at a levée. Chassepots, Sniders, magazine rifles and revolvers, firing their ten and twenty shots in a minute, Gatlings and Nordenfelts, firing their hundreds, would annihilate any regiment that attempted a dashing charge. The animal courage and brute strength which rendered the English soldiers irresistible, must give place to the skill and intelligence required to manage the new arms. Every Prussian in the late war was a man of education, and, throughout the campaign, was specially instructed by regimental classes in the science as well as in the practice of war. It was not true, in this case, as Napoleon used to say, that "God was on the side of the great battalions." The valour on both sides was equal, but the science and intelligence were unequal, and the campaign was won by the latter. France and Austria herself have recognised this, and are now spending vast sums in giving a higher education to their people.

A mere elementary instruction is of small value, except by way of preparation for this competition among nations. A scientific education of a higher kind is still better as a preparative, but even that is insufficient. There is a wide gap between science and practice, and this must be bridged over by men having technical information and special aptitudes. The history of science and its applications is as old as human history. From Tubal Cain, skilled in all metal work, to King Ptolemy Philadelphus, working with his furnaces and crucibles, through Dalton drawing atoms to

illustrate his Atomic theory, there is a consecutive history, which has ended in chemical arts that have added so much to the resources and happiness of mankind. From Eratosthenes measuring the earth, to the faith of Christopher Columbus in its rotundity, and the French savants measuring the meridian as the basis of a metrical system, there is a sequence of progress which may be interrupted but is never lost. The little fire on the solitary tower of Pharos made Ptolemy II. the first discoverer of lighthouses, and many intermediate inventions only culminated in the dioptric lenses of Fresnel and Brewster. The revolving engine of Hero, made practical by Avery, was the precursor of numerous inventions which led to the double-acting engine of Watt. No great discoveries are made by a bound; for all are legitimate offspring of those which have preceded. And though science lies at the foundation of the arts, her immediate cultivators are rarely the appliers of the knowledge which they help to discover. Science may be likened to a perennial stream with a bountiful supply of fertilising waters, but those who desire to use them must cut channels for irrigation. It is neither in the interest of science nor of manufactures, that the cultivators of the former should direct their attention from it in order to minister to the wants of productive industry. This is the proper function of the productive classes. Hence the necessity that they should receive a high education, so that they may apply science to their wants and necessities. This is now recognised pretty generally by manufacturers, who are content to admit that such knowledge should be possessed by their foremen and managers, though they do not see any necessity for it among the artisans. At least they act on this view in practice, even when they deny it in theory. I was lately attacked in a vigorous and effective way, for my views on technical education, by an eminent manufacturer in the north of England. To show my appre-

ciation of a worthy opponent, I called at his works, but at a time when he was obliged to leave them. He nevertheless politely instructed his manager to show me everything. I found that the manager was a Frenchman, who had received a thorough technical education at the *École des Arts et Métiers* of Angers! A distinguished engineer lately expressed a similar view in a lecture delivered in this city, and on that occasion he gave the following description of what should, and should not, be the education of a working man. His definition is as follows:—"Clearly every branch that can help him to perfection in work, but as clearly nothing that will simply occupy his time without furthering the all-important acquisition of manipulative skill." The engineer who wrote this is a man of professional attainments, but when I read the passage, I said to myself, "Does he view an artisan as a man made in God's own image, or as a mere ambidextrous monkey?" We need not be surprised, if such ideas are prevalent, that employers of labour speak of their workmen as so many "hands," and rarely think of or use them as having so many heads and hearts. This limitation of men to mere handicraft skill, in which their ten fingers work dissociated from their head and heart, has made poets rail against mechanical inventions, when in reality these, if rightly used and intelligently understood, are means of intellectual elevation, because their very purpose is to substitute the sweat of the brow by the thought of the brain.

It is, perhaps, natural that engineers should often be opposed to the creation of technical schools. They know that they have largely advanced the industries of the country when such schools did not exist. They feel with just pride that their offices and workshops have been schools for engineers, and have produced admirable men. It is true that the office of the engineer aims only to teach the apprentice manipulative skill and constructive work, leaving

him to pick up scientific knowledge where and how he can. When engineers see that schools and colleges are actually furnished with workshops in which mechanical drawing is thoroughly taught, and that pattern-making, moulding, and founding form part of the curriculum, and where an intimate acquaintance with the use of ordinary machine tools is given simultaneously with scientific education, the old engineers shrug their shoulders, and give scant encouragement to the new modes of technical education. Every one admits that English engineers in the past have efficiently trained young men by their system of apprenticeship. There are many other industries, like those of metallurgy, chemical manufactures, and textile fabrics, which have never given methodical training within their factories. For those who have to follow their pursuits, outside technical education is necessary. Even in regard to engineers a growing demand for more methodical instruction than that given in the workshop has arisen. It is stated by those who have especially attended to preliminary instruction in engineering that three years at colleges of this kind, combined with two years in the workshops, turn out better men than five years' apprenticeship in the latter. The proof of this is that there is an active demand for men trained in this way. On my last visit to the great technological school of Boston, I found a display of competitive designs for a particular kind of bridge. While I was looking at the drawings, the largest builder of bridges in America came in, and being much struck with the excellence of one of the designs, he sent for the student and engaged him at a good salary. The hundreds of students who pass through that school find no difficulty in obtaining employment, though at first their salaries are moderate, for they have much useful experience to learn in the actual workshops of industry. The reason for this is obvious: the object of a school is to teach, while that of the workshop is to pay, so the purposes of both must be brought into combination.

In former times all industries were taught by apprenticeship, which really afforded a good technical education suited to past periods, when industries were carried on by rule of thumb, and not on scientific principles. In past periods medical men were trained in the same way, until science illumined their profession, and then special technical education in it became essential for the safety of the public. Industrial occupations are acquiring the dignity of a profession, because they are now based on a knowledge of science. Science has, in recent times, produced so many applications, that the modern manufacturer stands at a great disadvantage when he is ignorant. The association of masters and apprentices, in regard to crafts, is a matter of history; for competition has converted it into that of capitalist and workman. The capitalist, with his large factories worked by machinery, has neither the time nor the inclination to bring up young men with a trained knowledge of his industry like the apprentices of olden times. Technical schools now intervene, and offer to teach the workmen, the foremen, and the managers the scientific principles lying at the base of their industries. The capitalist does not always encourage this intervention; he is inclined to rest content when the workman confines his labour and attention to one minute division of the industry, because constant application at that renders the labourer more economical to the employer. It is only when he sees the labour-market changing from places which neglect to those which promote efficient technical education that he awakes to the new conditions under which industries are carried on. It is surely creditable to working men that they should wish to have an intelligent acquaintance with the whole industry in which they are engaged, and not to remain satisfied with the mere empirical skill spent upon the small corner of work allotted to them in the division of labour. In addition to this desire there is also a practical

necessity for a more extended knowledge of their industry than is attainable in the workshop. The rapid improvements in machinery are producing constant dislocations in labour.

The true education of a labourer is to make him an intelligent being, not a mere dexterous manipulator, so that he may have the moral dignity and intellectual force derived from a thorough understanding of the principles of the work in which he is engaged. Instruction in manipulative skill is no complete education at all; and, such as it is, belongs to the workshop, not to the school. They may, it is true, be often combined with mutual advantage, as in the half-time system of factories and union schools, or in the way it is done in Scotch universities by winter study and summer work. If Faraday's education had been limited to that which bore on his manipulative skill as a newsboy or a bookbinder, many arts would be far behind their present position, and science might have had to wait another century for a knowledge of the laws which are now the property of mankind. Faraday's first experiment, made as a newsboy while waiting outside for a paper, was to put his head through a railing and then speculate on which side he was! Here we see the philosopher acknowledging the head as of preponderating importance, though it was incapable of being dissociated from the body. He got a practical proof of the fact that both ought to be kept in good connection; for, while he speculated, the door opened and he received a severe wrench. Faraday never afterwards dissociated his manipulative skill, great as it was, from his wise head and warm heart. If Wheatstone had limited his education to the manipulative skill of making musical instruments, space would not have been abridged or time abbreviated by the electric telegraph. If George Stephenson had only acquired the manipulative skill of shovelling coals adroitly into the furnace when he acted as a stoker, we

might still have to go from London to Edinburgh by a four-horse coach. No! the proper education of a man is the widest that is attainable by him, and the greater his knowledge the more useful will he prove to himself and to those around him.* It is, however, contended that these very instances prove that the great discoveries in science, and the great applications in industry, have been made by men of genius who never had any technical education. It is quite true that men of commanding genius have made their mark in the world without technical education, and that they have profoundly altered important industries, although it is probable that their difficulties would have been lessened had they possessed it. These great revolutions of industry

* As a contrast to the above description of what the education of a working man should be, I give another from a great practical body—the Steam Navigation Company the "*Messageries Imperiales*" of France. A committee of their Directors, in recommending a further development of their excellent schools, report as follows:—"The instructions to be given to the working man ought, in our opinion, to be such as will raise his intellectual and moral level, facilitate the practice of his trade, make him more skilful in his craft, increase his power of production, and consequently his own means and the common weal, by gradually suppressing the ignorance and vice which are the cause of so much misery and the ruin of families. In addition to the subjects taught in elementary primary schools, we think technical education ought to comprise—Man's duty to God, his fellow-creatures, and himself; the study and recitation of select passages in prose and verse; caligraphy; the rules of French grammar and parsing; complete practical arithmetic; the elements of geometry; the elements of applied physics; industrial chemistry; industrial mechanics; linear drawing applied to ornament, machines, and naval constructions; the rudiments of sanitary science; the elements of history, especially that of France; the English language; the elements of geography, particularly as regards France; and gymnastics. For those of our pupils who desire to become foremen, heads of workshops, managers of factories, and engineers, the preparatory technical instruction must have the same basis as for the workman, but be far more extended, so as to enable them to enter a school of arts or trades, or the Central School of Arts and Manufactures, which for the working classes may be regarded as the schools of application, just as the Schools of Bridges and Roads, the School of Naval Engineers, etc., are for the upper classes."

are generally produced by outside men of genius, who were not driving in the usual ruts of an industry, but viewed its needs from without. Possibly technical education might have contracted their originality and power of work, though I do not think it would, for genius is irrepressible. Nevertheless, the fact is true that the great revolutions of industry come from without and not from within. Watt, who transformed the steam-engine, was a mender of philosophical instruments, and first thought of the engine when called on to repair a model for the Andersonian Institution in Glasgow. There he got lectures in science, and the cross-fertilisation of this with his practical aptitude bore its glorious fruits. George Stephenson, the collier, had no facilities for early education—a subject of much regret to him in after-life: he took care that his son Robert, the eminent engineer, should have the fullest scientific education within his reach. Arkwright, who revolutionised cotton-spinning, was a barber, and from want of education lost much time in trying to discover perpetual motion, but at last triumphed in industrial invention by his mechanical genius. Cartwright, the inventor of the power-loom, was a clergyman, and certainly was not educated in technics. Hargreaves, the inventor of the carding machine and spinning-jenny, was a handloom weaver, and may be said to be an inventor from the inside of the industry: he was unquestionably illiterate. Many other names in science and industry, as Davy and Dalton, the druggists; Faraday, the bookbinder; Wheatstone, the maker of musical instruments; Bell of the telephone, who was a teacher of deaf mutes, are instances of genius from the outside, illumining the science or industry which they advanced by such gigantic strides. I do not at all dispute the fact that men of genius can overcome the defects of their education, and can surmount difficulties which would prove fatal to men who had not the gift of genius. Such men are rare in

the history of the world, and education is not modelled to suit their needs. The men who carry on the great industries of nations are rarely in this category, and do benefit by a training of their intelligence in direct relation to their respective occupations.

The working man should be a partner in the intellect of labour. In our country his share is miserably small. Brain may monopolise, in the persons of the managers, 95 per cent. of the intellect, and allows the 5 per cent. to be spread over perhaps a thousand "hands."

Having said so much in regard to the principles of technical education, I now propose to illustrate them by showing how certain countries have conquered nature, and made for themselves important positions, in spite of local disadvantages or deficiency in the raw materials of industry, and then we will take a contrast to heighten the effect of these examples. My illustrations will be Switzerland, Holland, and Scotland; their contrast must be Ireland. The three countries have some common features, in the fact that their civilisation has been retarded by cruel and bloody wars of independence, and by those resulting from religious intolerance; yet all of them, owing to the education of their people, enjoy an amount of material prosperity disproportionate to their area and geographical position.

Let us begin with Switzerland. It is a country far removed from the ocean, and girt by mountains, many of which are covered with eternal snow. Her land is poor in the raw material of industries. Even in such a staple as iron, she can only produce two-fifths of her consumption; for fuel, she has only wood, and must import coal from the mines of France, Belgium, and Germany. Until 1864, the surrounding countries drew a cordon around her by hostile tariffs, so that this small nation presented the strange spectacle of seeking an outlet for her manufactures in the most distant markets of the world. To show you how little

the raw material of manufacture compares in value with the skill and intellect applied to its production, I may mention that Switzerland imports cotton from America, and sends it back again across the ocean in a manufactured state, so as to undersell the products of the American mills. In like manner she imports tobacco from Havannah, and making it into cigars, undersells the indigenous country in the South American markets. Now the question before us is—What has enabled this little nation, so remote from the pathways of commerce, and so poor in the mineral resources of industry, to carry on manufacturing production by the aid of a prosperous and contented people, while England, washed by the ocean, and abounding in mineral wealth, is burdened with an ever-increasing proportion of the unproductive poor? There is only one answer—that Switzerland has a highly educated people. Education in that republic, where liberty has long asserted her independence, is compulsory from five to sixteen years of age. In one or two of the cantons this is not the case, but even in these, from the force of the surrounding examples, there is no need of compulsion. The compulsion is both direct and indirect—that is, it extends not only to the parent, but also to the employer of labour. From six years of age to twelve or thirteen, the children must attend primary schools, which, as the age advances, become practical in the character of instruction; for, instead of being confined to the miserable "three R" standards, they include geometry, natural history, geography and history, drawing, singing, and calisthenics, all of which are rendered compulsory. After this elementary course of six years, follow three years at what are termed the "improvement" schools, in which every effort is made to apply to practical purposes what has been learned in the primary school. These improvement schools must be attended, or proof must be given to the State that the scholars are receiving equally good instruction elsewhere. Then come the cantonal schools of a high class,

like our High School and Academy, but divided into two quite distinct divisions—the classical and the trade schools. Any of us who have visited them can testify that, as classical schools, they leave nothing to be desired, when compared with our own standards, while we have no analogies at all to the trade schools, in spite of our wealthy endowments, managed by merchant and trading companies. The little Canton of Zurich, with a population midway between that of Edinburgh and Glasgow, has sixty-seven of the various secondary schools to which I have alluded. Above them all, are two universities. The University of Zurich belongs wholly to the canton, and is supported by it. The professors are 42 in number, and have 29 assistants. They are men of eminence, and do their work well; but the demand for this university is not nearly so great as for the Technical Institute, to which I am about to allude. This great institution is supported by the Federal Government. The canton supplied the buildings, which are larger than those of Buckingham Palace, and, in addition, subscribes a large annual sum in its aid. In it there are 40 professors and 20 assistant-professors, who have 700 students in attendance. In our own university we rather boast of having 20 or 30 students of engineering. At the institution in Zurich there are 150 for civil engineering and 169 for mechanical engineering. Of the 600 matriculated students, there are 216 from Germany, but only 9 from England. I wish every Edinburgh citizen could inspect this noble institution, with its two sets of splendidly equipped laboratories, its excellent apparatus, and its educational museums. I am sure that then the pride, as well as the interest of the Scottish metropolis, would not let our university be so poorly provided with educational appliances as it is at the present time.* Recollect that I am speaking of a small State,

* Since the date of this address the University of Edinburgh has built new laboratories, and is now amply equipped with the means for teaching the sciences.

republican in government, and inhabited by a thrifty and prudent people. Is it not significant that they find it for their interest to spend nearly one-third of the local taxation of the industrial canton in the lower and higher education of their youth? This frugal people do so because they find that such expenditure is productive of the best economies. The Coventry ribbon trade, which has deserted England, has settled itself in the valleys of Switzerland. The Polytechnic Institution has aided in this result, because it turns out 72 persons annually, trained in the science and art requisite to conduct such a manufacture successfully. In this single branch of the ribbon trade there are already 30,000 weavers, besides the collateral workers, such as dyers and superintendents. The ribbon trade of Switzerland is prosperous and increasing, having an annual value of £1,600,000, most of which is export, while the Macclesfield and Coventry trade, languishing and pining, has her exports represented by only £61,000. And so our Coventry weavers shout for protection for native industry, or, in other words, for native ignorance. The difference between the Swiss trade and the Coventry trade is very simple; it is involved in the answer given by Opie, the painter, to a youth who asked him how he mixed his colours,—"I mix them with my brains, sir!" In the one, high science and art superintend every branch of the industry, and a trained intelligence sits at the loom. In the other, the first is represented by a practical empiricism, the latter by ignorance. As long as this is the case, no reciprocal treaties which man can devise will raise an industry declining from natural causes. Laws of nature are inexorable, and never vary like human laws. Our operatives may find restored prosperity by putting themselves submissively into harmony with them, but never by seeking refuge in the worn-out economical policy of a past age.

Our next illustration is Holland, a country at the mouth

of the Rhine, while Switzerland is at its source. It is, in fact, formed by the débris of the Swiss and German lands, carried down towards the sea by that great river. Naturally it is nothing but a gigantic swamp, which has been drained and converted into a fertile country by the untiring industry of its inhabitants. Over this swamp the North Sea used to lash in fury, but was gradually pushed back by dykes. There is a constant warfare between man and the ocean in this strange country. During one of these conflicts of the thirteenth century the North Sea was victorious, and, breaking through the ramparts built to exclude her, robbed Holland of a province larger than Yorkshire, and formed the gulf known as the Zuyder Zee. In the sixteenth century another invasion of the ocean was again successful, and the Haarlem Sea was the result of the victory. But the Dutch people are lustful of conquest, and carry on constant war, not through blood and rapine, but by industry and science. Within a few years Haarlem Sea has been won back from the ocean, and 45,000 acres have been reclaimed for the people. In fourteen years from now, in all probability, the Zuyder Zee will be thrown back into its parent ocean, and a province capable of supporting 250,000 inhabitants will be added to the country. These are great achievements, and show that Holland is peopled by an intelligent and industrious race. Yet that country had few natural advantages in its dismal flats and dreary swamps. At one time, indeed, a favourable maritime position enabled her merchants to be the carriers for a large part of Europe. But this national monopoly has long ceased to exist, since navigation has been improved, and the wealth of the country is now largely derived from productive industries. For their prosecution Holland has fewer advantages than Ireland. With the exception of a small coal-field around Limburg, there is none of this important fuel in Holland. Yet, despite her natural poverty in the raw materials of industry, Holland sends to

this country alone exports of food to the annual value of five millions of pounds, and manufactured products worth six millions more. Recollect that we are not speaking of a great State, but only of a small kingdom, having one-tenth the area of the United Kingdom, and one-eighth of its population. The secret of her prosperity is the high state of education among the people, though, from want of a compulsory law, there is still a residue of ignorance. In the primary schools of Holland, a wide foundation is laid for practical purposes in the attention given to science. Beyond this primary instruction, there is a complete scheme of technical education, not only for workmen, but also for the foremen and managers of works. The law compels every town of 10,000 inhabitants to erect technical schools. In these, working men receive systematic instruction in mechanics, natural philosophy, chemistry, natural history, technology, agriculture, geography, history, the native language, political economy, freehand and mechanical drawing, and calisthenics. Above these are the higher technical schools, of which there are thirty-two in Holland—twelve, I believe, being supported by Government and twenty by municipalities. In them are 2,500 pupils, who pass through a course of five years, about one-third of it being devoted to the study of the exact sciences, one-third to the political, mercantile, and historical sciences, and one-third to their own and at least two foreign languages. When you go into a shop in Holland, you feel quite secure that the shopkeeper will speak either English or French, and generally both. Such liberal salaries are given to teachers that they are readily obtained. Neglecting a few country parishes in which poverty prevails, the minimum of their salaries is £100, and the maximum £350. Need I say one word more in explanation of the causes which make Holland an industrious and prosperous nation, in spite of its small area, and poverty in industrial resources?

Lastly, I select Scotland as an illustration, not for what education will do for her in the future, but for what it did for her in the past. Scotland was still a country of savages when Ireland had the elements of civilisation and the promise of increasing prosperity. I need not remind you how long the Scotch wars retarded the development of industry. So deplorable were they, that the very treasures of our coasts were taken away by other nations, for the Dutch worked our fisheries to the extent of two millions of pounds per annum for two centuries before we had leisure or enterprise enough to do it for ourselves. How long it took to cradle our industry may be known from the astonishing fact, that there was an actual slavery or serfdom among the colliers and salters till nearly the end of last century. Though the Union gave a great impulse to trade in Scotland, by a relief of the navigation laws, yet it required another century to improve the roads and means of communication sufficiently for the purposes of commerce. About a century since, £200,000 sufficed as a circulating medium for all the wants of commerce, agriculture, and manufactures; now we require four and a half millions of notes, and two and a half millions of coin. The reason for the rapid rise in the industrial prosperity of the country was that there had been a long preparation for it in the education of the people. As soon as the natural obstacles to commerce were removed, the people were ready to do their part with energy, and to take advantage of the richness of our natural resources. A national system of education, and an easy access to the four universities, had given to them advantages far exceeding those available to the people of England * or

* At one time, in the sixteenth century, the English universities were chiefly attended by yeomen, and the poor had ready access. "In times past, when any rich man died in London, they were wont to help the poor scholars of the universities with exhibitions. When I was a scholar in Cambridge myself, I heard a very good report of London, and I knew many that had

Ireland. I need say little more, as I dwelt upon this subject in a former address, yet it is important to consider whether Scotland is now in the position to retain this proud pre-eminence. Her parochial system of education does not apply to towns, and her schemes of secondary education are imperfect. Possessed of wealthy endowments for educational purposes, they are worked so as to be positively injurious to the progress of the people. While England is in a state of the greatest activity for the reform and extension of primary education, and holds meetings of great unions and leagues in every town, Scotland is asleep and is dreaming of her past glories. While England is about to reform all her educational endowments, by throwing them into one grand scheme of secondary education for the whole body of the people, with the agency of responsible commissioners nominated by the Crown, Scotland has allowed her endowments to remain under irresponsible corporations, who seem to have no inclination to give up their patronage and class privileges for the benefit of the nation. How much longer Scotland intends to sleep on I do not know, but the world at large sees clearly enough that the *lions passants* of England on their four feet are now making much more way than the *lion rampant* of Scotland on its two hind legs. It was not by dwelling on the past that John Knox laid the basis of prosperity for his country. Past glories ought to be honoured, but future glories require to be achieved.*

Lastly, I bring Ireland into contrast with the three countries which I have described in their relations to education. She has had troubles, even more severe than

relief of the rich men of London, but now charity is waxen cold, none helpeth the scholar, nor yet the poor. Oh, London! London! repent, repent, for I think God is more displeased with London than ever He was with the city of Nebo."—Latimer's *Sermons*, vol. i., page 64.

* Since 1870, many of the educational endowments of Scotland have been efficiently reformed, while the Education Act of 1872 has worked admirably for the better education of the towns.

those of the Netherlands under Philip II., or of Switzerland and Scotland in the Wars of Independence. Worse than these wars of conquest and rebellion has been the ruthless stamping out of her industries, as they began to appear above the surface of the soil. In the whole history of Protection, nothing is so deplorable as the ills which it has brought on Ireland. Only a single industry, that of flax, has been strong enough to resist the prohibitory laws of England against exportation. Even the internal industries of the country were paralysed by the protective spirit, which, in the form of bounties, robbed the people of their self-reliance. The channels of industry being closed, the people flowed over the land, which, under excessive competition, rose to rack rents, and the tenants scourged it in order to obtain a return. Thus, even the national industry of agriculture has gone to the bad, for the soil of Ireland, impoverished by bad cultivation, has lost the ability within the last ten years of feeding nearly two millions of the population. Supposing that this had not been so, agriculture possesses only a small power of expansion when compared with manufactures. I have shown you by the examples of Switzerland and Holland, that poverty in natural resources is no bar to industrial development, if the population possess an educated intelligence sufficient to compensate for their local disadvantages. There is nothing inherent in the soil, in the Celtic origin of the people, or in the religion of Ireland, that should prevent it becoming an important manufacturing country, for all of these conditions are represented in other prosperous nations. The chief difficulty for its development consists in the fact that England has impressed a character upon the people by centuries of misrule, and that time is requisite for the change of character; because a State, responsible for the upbringing of a people, cannot escape the judgment which says that the sins of the father shall be visited on the

children, even to the third and fourth generation. Ireland, though possessing but little coal, is near to the coal-fields of Scotland and Wales, nearer, in fact, than many parts of England, and far nearer to such fuel than Switzerland. She possesses fine rivers and unequalled ports. Her climate is specially favourable to the spinning of cotton. Her wool, hides, and tallow point to manufacturing woollen fabrics, leather, candles, and soap. Yet only one-half of the people are engaged in trade and manufactures that ought to be so occupied, according to the experience of England and Scotland. No measure of improvement which stops at the notion that agriculture is sufficient for the people, can make Ireland prosperous. The quickest remedy for the ills which afflict her will be the secondary education of the people in practical subjects. It is only through such education that you can diminish the craving hunger for land, and raise a desire for other forms of industrial occupation. It is true that Parliament has already expended much money in giving what England calls primary education to the people of Ireland. Well, if that were enough, Ireland should have ceased to be England's difficulty, for there is a wider diffusion of the three R's in the former than in the latter country. And what has it all come to? That the Irish have been enabled to read the seditious newspapers of their country, and, like Caliban in the *Tempest*, to turn upon us and say—

> "You taught me language: and my profit on't
> Is I know how to curse:"

Such miserable instruction as we give to working people under the name of education, can produce no better result in a disaffected population. For them there is no hope of a higher education in the practical sciences of life, such as is given in other countries. In Scotland, out of 3,500 students at the universities, probably 500 are sons of the

wage-making class. In all the Queen's Colleges of Ireland, since their foundation, the Vice-President of one of them writes to me that he recollects only one instance of the sort, though there are many sons of farmers holding twenty or thirty acres. If we except the half-dozen royal scholars to Trinity College, Dublin, who are now graciously allowed to wear velvet caps, there is no aid to the poor from this quarter. So the education of Ireland, in its present condition, has but small ameliorative power on the working classes; for it possesses none of those powerful means of pushing forward the meritorious poor which were long the characteristics of Scotch education. Where instances occur of nations abounding in paupers and criminal classes being made prosperous and happy in less than a generation, through the powerful influences of education, that has never been confined to a smattering of the three R's. Such an instance is Baden, which, by eight years of industrial education, lessened the number of prisoners from 1,426 to 691; to such an extent, indeed, that prisons had to be closed for want of occupants. The technical education which led to this result was not only high but special; and, through its agency, new industries were introduced into the country, and declining industries were revived. If we think direct schools for teaching not merely the principles but the actual practice of special industries are generally impolitic for a State to encourage, let us honour and recognise the exceptions to our rule; for, in the case of Baden, they have made a poor population prosperous and happy. Like results, by the same means, have been attained in West Flanders, and the nuisance of mendicity, with which that province was affected, is wholly abated, just as it was at the end of last century in Bavaria, under the administration of the American schoolmaster, Count Rumford. So it is in Silesia, in which the poor population has been vastly benefited by the industries thus introduced through the agency of special

technical schools. Without declaring myself in favour of actual industrial schools of this kind, I would much desire to see secondary or improvement schools for teaching practical science and art made available to the artisan class in Ireland. It may be that the artisans thus trained will not be absorbed by Irish industry as quickly as they are produced, but they would be readily drafted to other countries, just as the Swiss are at present, for their higher schools educate more scholars than are required by Switzerland. The absorption of the surplus of educated Irish artisans would be beneficial to Great Britain and the colonies, and would have a most powerful reflex action on Ireland. Agriculture would then cease to be the only industry kept before the eyes of a great part of the population of Ireland; while new thoughts, new ambitions, and new occupations would raise the population of Ireland, as certainly, if not so rapidly, as similar causes have raised Scotland within the last century.

Having now, I trust, established that a high education of the people in a country gives to them the conditions of industrial success, I would direct your attention to the difficulties which present themselves to the adoption of a system of technical instruction in England. Every effort made to promote it is met, both in Parliament and out of it, by the statement that it is in vain to ask the tax-payer to augment taxes for such a purpose, as he already pays more for education than any tax-payer in the world, notwithstanding that the results are confessedly miserable. Compare, said a statesman to me on a recent occasion, our educational expenditure with that of France, Germany, or any other great State, and you will find it both absolutely and relatively greater. Let us, then, make the comparison with France, for, next to England, she stands lowest as regards the primary education of her people. Well, the first thing that meets our eye is that the educational expenditure of England

in this year (1870) is £1,390,000, while that of France is only £776,000. So stand the figures on the budgets of the two countries, and, if they were susceptible of no explanation, it would be a deep cause of humiliation to us, for France, though not in the primary, yet in the secondary education of the people, is far ahead of England. The figures assume a very different aspect if we add the municipal taxation for education in France to the amount of imperial taxation.

	France	England.
Public taxes for primary education . .	£2,116,994	£1,023,071
,, ,, ,, secondary and higher education	506,241	368,525
	£2,623,235	£1,391,596

So that in reality France taxes herself for education nearly twice as much as England does.* Doubtless, in our case, voluntary subscriptions supplement Government expenditure, but these have nothing to do with the present grumbles of the tax-payers. The reason why England receives so much from the imperial funds, and yet has only about half the educational resources of France, is that our country has fallen into a great educational error. Other countries consider that primary instruction is the duty of localities, and ought to be supported by local rates, the duty of Government being limited to superintendence and inspection of the schools, or to supplementing the salaries of teachers. This will be seen clearly in the French budget, which applies only £260,000 to subjects of primary instruction, the remaining £500,000 being devoted to higher education. You observe that nearly twice as much is spent on the latter, while in England the very reverse system is

* Since 1870 both countries have largely increased their educational expenditure. France has spent very large sums in improving secondary and university education; while the United Kingdom has raised the Parliamentary votes, so that in 1888 they reached £4,822,471.

pursued—two-thirds of the expenditure being on the lower, and only one-third on the upper branches of education. Do you begin to see that England, with all her apparently high educational expenditure, is in reality spending, both absolutely and relatively, much less than France, Austria, and Prussia, and far less proportionally than Holland, Switzerland, and many other nations? Yet this error of loading the Exchequer with burdens which ought to have fallen on localities, has made a heavy educational difficulty for the future. England has taught the localities to look to the Treasury for payment of their primary education, and they are not now willing to accept the natural burdens which have been imposed upon them in all other countries. Foreign States have rightly understood that the functions of Government are chiefly to promote the well-being of the people, by giving to them such higher educational development as will enable them to compensate for disadvantages in local position, or lack of raw material, or sterility of soil. England, on the other hand, until recently, has been content, as an empire, to discharge the duties of a hamlet; and when science and art look for aid to develop themselves as in other countries, the Chancellor of the Exchequer shakes his head, and the Premier cheers the Vice-President of the Council when he deprecates the increase of taxation. I aver that our educational expenditure, instead of being the largest, is least among the great States. Nevertheless, if the localities assumed their natural burdens, as in other countries, our present amount of imperial expenditure would probably suffice for the higher education of the people. It will be a long time before the localities will wean themselves from looking to the imperial funds for aid in primary instruction, so, if we desire to see a higher education of the people, we must either seek the means in increased taxation, or preferably in the conversion of unproductive into productive expenditure. It cannot be for

ever that Europe will spend 140 millions, or 32 per cent. of her total expenditure, on standing armaments. When I gave this address in 1870, the United Kingdom spent £400 out of every £1,000 of expenditure on the army and navy, and less than £20 on education. In this year, 1888, the war expenditure remains the same in proportion, while that for education has mounted to £60. This is satisfactory, though we may well hope that the time will arrive when protective expenditure will be lower and productive expenditure will be still higher.

I do not know how far I have carried you with me in my arguments; but I trust that I have given good grounds for some of them, so far as our time permitted. The whole ideas of education are travelling back to the position that John Knox left them in three centuries since. At one time it was an almost accepted rule, that there should be a liberal education for a gentleman, and a limited one for a peasant. John Knox taught us that there should be one education for a MAN, who ought to be able to equip himself for any vocation in life that his talents justified him to assume. And this comprehensive conception of education was, at the same time, the glory and power of Scotland. England has not yet fully realised this, and still keeps its primary schools to the narrow limits of the three R's. Scotland has not allowed herself to drift to this narrow view. Scotchmen hitherto have entered life covered with the armour of knowledge, and able to fight their way through difficulties. Instead of the old thick armour-plates of knowledge, the Privy Council wish to cover your children with the thin veneers of the perishable three R's. Which of them will crack first in the conflict of life?

In conclusion, let me ask you seriously whether you think that this country can continue in a career of prosperity, when she is the only leading State in Europe that is neglecting the higher education of the working classes, and

of those men above them whose duty it is to superintend their labour? True education consists in fitting a man for a complete life. That is no education at all which gives him knowledge useless for the activities and duties of his existence. I have said that science and art must be studied for their own sake by those who try to advance their boundaries; and are only available to producers who know how to apply the discoveries of philosophers. Science is like the fertilising rain, which invigorates crops growing on land fitted for its reception, though it runs to waste, without percolating the soil, if that be hard and untilled. So, just in proportion as different States prepare their population by culture, will they increase in strength or dwindle in weakness. The future histories of the world will not be those of blood and rapine. They will recount the achievements of those nations which have ameliorated the conditions of the human race by the discoveries and applications of science. It is for the United Kingdom to determine whether she desires her history to be that of a country which was raised to the highest place among States by the genius of mighty men, though she lost that position by a blind reliance on the practical empiricism of her people; or whether her future history is to be that of an enlightened nation which, seeing that a general diffusion of science and art is giving to other countries advantages in industrial competition, added this intellectual power to the practical aptitude of her population. It is a truth incapable of being gainsaid, that science must be joined to practice in the advancing competition of the world, in order that a nation may retain the strength and energy of manhood; for States, like individuals, fall into decrepitude and decay.

ON TEACHING UNIVERSITIES AND EXAMINING BOARDS.

This address was given in 1873, when the Irish University Bill was brought before Parliament.

THE subject of this address has recently received a large amount of attention, on account of the able speech of the Chancellor of the Exchequer, delivered at Halifax. Mr. Lowe represents a university of a peculiar character, unlike all other universities since the time when the conventual institutions of Charlemagne and King Alfred crystallised into an academic form. The University of London is a mere Examining Board,—one, it is true, of high character, but having none of the traditions or habits of any other European Universities. It is, as I will show hereafter, far more related to the Examining Boards of China than to any European model. Captivated with the spirit of the university which he represents, Mr. Lowe has announced startling views as to the position which the State should take in relation to the universities of the kingdom. You are no doubt aware that a statesman in a position of responsibility, is inclined to speak like a Delphic oracle, and so we are never sure what interpretation to put upon words which often cover an unavowed or mere tentative purpose. I happen to know, from an active correspondence which Mr. Lowe's speech has brought upon me from the Irish and Scotch universities, that they, at least, have come to a single interpretation of his meaning. They conceive that the immediate, though not the expressed, purpose of his speech, was to prepare the public mind for the conversion of the

teaching universities of Ireland into a joint Examining Board like that of London; and that, as a later operation, the four Scotch universities would be requested to execute upon themselves the Japanese operation of the "Happy Despatch" in a like manner. Mr. Lowe's general thesis is this—that it is not the duty of the State to assist higher educational institutions, though it is the duty of the State to control and regulate the examinations in them. His words are:—"What the State ought to have to do with the universities is to decide of what the curriculum should consist, or list of subjects on which the examination should be held." He defines a university as follows:—"What I mean by a university is an examining board;" and of these boards he would found two or three, perhaps only one, like the University of France, for he says "the fewer the better." Mr. Lowe lauds the University of London as the type of all that is excellent, and compares with it, to their disadvantage, the other universities of the kingdom. Any opinions coming from a man of such distinction and political power as Mr. Lowe demand careful attention, and more especially when we connect them with opinions which Mr. Gladstone has expressed in relation to the Scotch universities, and is supposed to have shadowed out as principles for the reconstruction of the Irish universities. If a University of Edinburgh and a University of Dublin, as mere examining boards, swallow up the graduating powers of the Scotch and Irish universities, the inexorable logic of events must compel the University of London to swallow, although the pills are larger, the Universities of Oxford, Cambridge, and Durham.

If the Chancellor of the Exchequer really intended to throw down the gauntlet on such an important issue, I am a small knight, and of low renown, to take up the gage of such a doughty champion; but I should be unworthy of the confidence bestowed upon me by two Scotch Universities if I refused to consider the question in relation to its public

policy. I therefore propose to show to you that there is already ample experience to guide our policy in this matter, and the result of it has been, that wherever a State has destroyed the separate autonomy of universities by establishing common examining boards, disastrous effects on the national character and national intellect have ensued; and further, that in the single case in which an examining university—that of London—has been established as supplementary to other universities, the effect upon the higher education of the people has been singularly small. I must begin by denying altogether Mr. Lowe's definition that "a university is an examining board." There is nothing in history to justify this definition, except the single instance of the University of London, founded thirty-three years since.

From the very earliest days, the teaching and examining functions of universities have been united. The first time perhaps that the term "university," in relation to a seat of learning, appeared in an official document, was in 1209, when Pope Innocent III. included the whole corporation of teachers and students "*Doctoribus et universis scholaribus Parisiensibus . . . universitatem vestram rogamus*," etc.; and the style taken by that university in 1221 was, "We, the university of the masters and scholars of Paris." Before that period degrees were given, and their organisation was even regulated by a Papal Bull. I need not remind you that all European universities, except the University of London, are founded on separate or mixed types of the ancient universities of Paris and Bologna. If students and teachers were essential, in their corporate capacity, to a graduating system in Paris, you may be sure they were so in all other universities; for Paris was a "*Universitas Magistrorum*," which retained the chief power in the hands of the teachers; while Bologna was a *Universitas Scholarium*, and gave the preponderance of power to the students. We all know that the term "graduates" originally

meant graduation in the office of qualified teachers; for all university graduates had not only the power but were under an obligation to teach. So essentially was the union between teaching and graduation deemed a part of university existence, that when universities began to split up into colleges, the separate colleges were not unfrequently empowered to grant degrees, though the superiority of the university, as a whole, was recognised by the visitorial powers of the rector. Thus the College of Sorbonne became practically the faculty of theology, and granted degrees with the consent of the Chancellor of Notre Dame. The other professional colleges in Paris united into faculties, and their deans granted degrees in like manner. As it was in Paris so was it in Bologna. From and after 1362 there were actually four degree-conferring universities in Bologna; two for law, one for medicine and philosophy, and one for theology—the degrees being conferred by the regent doctors, that is, by the professors in each. In our own country, in 1468, Pope Paul II. granted to the College of St. Salvador in St. Andrews, the full power of granting degrees; and his successor, Paul III., in the following century, gave the same power to St. Mary's College. In Aberdeen the case became more marked, for two colleges became two distinct universities in the same town, and have only been united in our own day. It was somewhat different in the English universities, where the colleges gradually usurped the principal teaching functions from regent graduates of the university. These duties have, however, been preserved in theory, though relinquished in practice, by the professors, who are the representatives of the old regent graduates. Within the last few years the original practice is beginning to reassert itself, for the professors of the natural and medical sciences, with their assistants, do the whole work of teaching. In Scotland the teachers carried within the walls of the college the graduating powers of the university; for the

colleges, which were rather homes and refuges for professors than for students, became the university; while in England, the colleges, arising out of students' halls, carried away the teaching functions of the university, although they were unable, or too careless, to carry the graduating power along with them. The German and Italian Universities are similar to those in Scotland, and have preserved unimpaired the original and intimate union between the teaching and graduating powers.

France has completely separated these two functions, and its university forms an excellent study for those who would advocate a State interference with university examinations. I have alluded to the early history of the University of Paris, when its teaching and examining functions were united, and for nearly six hundred years it produced men of intellect and men of action, who made France the wonder and admiration of nations. The provinces of France imitated the University of Paris, and, before the great Revolution, twenty-three universities, each with a separate autonomy, were spread over the kingdom, adding largely to its intellectual productiveness. These provincial universities were destroyed by the great Revolution. Napoleon I. reconstituted the University of Paris in 1808, by making it the single university for France. The University of France now became the department of State instruction, and included every kind of education, Primary, Secondary, and Collegiate. The State in France now received, in its highest form, that function which Mr. Lowe has announced to be the duty of the State, the dictation of the curriculum and the examination of scholars. It carried on this double function for more than sixty years, and thus has had a more prolonged trial than French institutions of any kind usually enjoy; but the result has been, in the opinion of the most eminent Frenchmen, that its operation, more than any other cause, has led to the humiliation of

France as a nation. Recent events have strengthened the conviction which De Tocqueville expressed twenty years ago, that there is a continually increasing poverty of eminent men in France. I will cite the evidence only of men of the highest eminence, Members of the Institute, or Professors in the university itself. Their opinions may be taken as answers to the question which forms the title of Pasteur's pamphlet: "*Pourquoi la France n'a pas trouvé d'hommes supérieurs au moment du péril!*" That is a grave question for France, and its best sons are trying to answer it; but it is melancholy to see the assaults that they are obliged to make on a university which, in its days of independence, used to be hailed as "the fountain of knowledge," the "tree of life," and the "candlestick of the Lord"—terms which were accorded by the enthusiastic admiration of all countries. First let Pasteur, whose eminence I need not advert to in an academic assembly, answer for himself:—"While Germany was multiplying its universities, and establishing among them a most salutary emulation; while it was surrounding their masters and doctors with honour and consideration; while it was creating vast laboratories furnished with the best instruments, France, enervated by revolutions, always occupied with sterile aims at a better form of government, gave only a heedless attention to its establishments of higher education." The unanimity is surprising with which eminent men ascribe the intellectual paralysis of the nation to the centralisation of administration and examination by the University of France. Claire Deville says—"The success of Germany is due to the liberal organisation of the German universities. It is science that has vanquished us." Dumas, one of the most eminent men in France, formerly a Minister, and for years actively engaged as one of the eight Inspectors of Superior Instruction in the University, gives his testimony as follows: "If the causes of our marasmus appear complex and manifold, they are still

reducible to one principle, administrative centralisation, which applied to the university has enervated superior instruction." He proceeds to show that municipalities and provinces lose all interest in their colleges and schools when these are deprived of their powers of self-government, and when their instruction and their examinations are regulated from a centre, and he contrasts the French system with that of other countries. "In Switzerland," says Dumas, "in Sweden, Germany, England, and the United States, numerous universities, diverse in their origin and tendencies, each having their own budget and management, which they direct for the best interests of their students, prosper, on account of their separate life and autonomy, offering to us a spectacle full of interest." Dumas then indicates what is necessary for the restoration of France to her position among nations: "Restore to our universities, under the surveillance of the State, when connected with State grants, the independence which they enjoyed before the Revolution. The great men of those times are glorious historical witnesses of the vigour of the studies, and of the discipline effected by the liberty of education enjoyed by our fathers. . . . I plead for the autonomy and liberty of our universities." Quatrefages, General Morin, and others, express themselves in nearly similar terms. Lorain, Professor in the Faculty of Medicine, gives testimony if possible still more emphatic: "The University of Paris now influences higher education only through the faculties of law and medicine, for though the schools of literature and pure science have still their professors, they have no longer pupils." He tells us that a central university, professing to direct everything, really directs nothing, but it trammels all efforts in the provinces. "Originality in the provinces is destroyed by this unity." After quoting the opinions of the Commissioners of 1870, as to the want of unity of degrees in France, notwithstanding the unity of examination, he sums up the

demands of reformers in the following words :—"What we demand is not new; it is simply the return to the ancient system, to the tradition of the ancient universities. We demand the destruction of the University of France, and the creation of separate universities. That is our programme." I have hitherto quoted the opinions of men of science, but I might add to them those of a long list of politicians and men of literature, from Talleyrand, Turgot, De Tocqueville, Prévost-Paradol, down to the present day; but to economise time I must content myself with two more quotations. In a letter to myself, Michel Chevalier, after stating that the liberalisation of the university frequently engaged the attention of the Senate during the last Empire, sums up his opinions of the necessary reforms as follows :—"Much more of autonomy in our faculties than they have at present, even for those which are supported by the State; a large vote for their maintenance in the budget; liberty for individuals and associations to found rival faculties : reservation to the State, under equitable guarantees, of the right of granting degrees as long as there are degrees." And finally, I quote the words of Renan :—"The system of examinations and competitions, on the great scale, is illustrated in China, where it has produced a general and incurable senility. In France we have already gone far in the same direction, and that is not one of the least causes of our abasement. The paltry faculties created by the first Empire in no way replace the great and beautiful system of rival universities, with their separate autonomies—a system which all Europe borrowed from France, and which all countries but France have preserved. We must create in the provinces five or six universities, each independent of the other." I have already quoted too much; but you will deem it to be very surprising that the system which has so much injured France in the past is to benefit England in the future. France has not failed because she was deficient either in

institutions, teachers, or pupils. Of all three she is far richer than this country. Her *lycées* were full, and the number of their pupils has been eulogised by Matthew Arnold. Her higher institutions were numerous—eight schools of law, five of medicine, eight for science, and six for arts. But they were separate schools, such as Mr. Lowe hopes to see arise by private efforts; they were not, with the single exception of Strasburg, united faculties working together; they had no university organisation, none of the activity of little intellectual republics; nothing to nourish or stimulate the independent growth of intellect throughout the nation. An empire of thirty-eight millions of people had only one university, situated in the capital, and that one subject to the State. It thought that intellect might be fostered by special schools acting as organs to one great nervous centre; but the organs have not fulfilled their functions, and the nervous centre itself has consequently dwindled away.

The mode of granting degrees in Belgium is instructive and peculiar, and as it is triennially reported upon by the Minister of the Interior, its results can be fully studied. To that Minister, and to my friend Senator Fortemps, I am much indebted for full information on the system. The 17th Article of the Belgian Constitution declares education to be free, and, in the spirit of that declaration, the mode of granting degrees has been adapted to schools of all kinds. But difficulties have been experienced in the practical working of the measure, and consequently the laws relating to it are frequently altered. The substantial law, now in operation, is that of 10th June, 1857, as amended in 1861 and 1865. To understand its operation, I must remind you that Belgium possesses two State universities, those of Ghent and Liège, and two "free" universities, maintained by communal grants and private endowments, at Brussels and Louvain. At all the four universities there were 1,898 students in the year 1869-70. The university system is

therefore developed to about the same extent as in Ireland, both being Roman Catholic countries. In Belgium there was in 1872 one student to 2,600 of the population; in Ireland one to 2,700. In granting degrees the universities are divided into two groups, so that one State and one free university are in each. A combined jury is formed for the group by the nomination of an equal number of professors from each of the two universities, and a president is appointed by the State, selected on account of his high and independent position. The candidates for degrees must first establish, to the satisfaction of the jury, that they have passed through a well-ordered curriculum of study, and their certificates must prove "*que la fréquentation des cours universitaires fut* ASSIDUE . . . . . *et* FRUCTUEUSE." Theoretically, a candidate may present himself without such certificates, if he have studied privately, but then he must go through a severe preliminary examination, in order to show that he has studied systematically and efficiently; practically, no private candidates do go before the Academic juries. For private students the Central Jury of Brussels was organised. That jury also consists of professors, but half of them are from the universities and half from private institutions, the president being a man of position. The candidates must first prove by certificates that they have gone through a regular curriculum of study, or submit to the examination already referred to. Previously to 1867 this jury had numerous candidates, and the supposition was that they represented private instruction, but suspicions having arisen on this point, it was determined, on the recommendation of a Commission, that the Central Jury should hold its examinations *before* those of the Academic Juries, the former practice having been to hold them after. This change was made at the beginning of 1867, and it produced a startling result. The candidates for degrees now disappeared, as the Minister of the Interior says

'*comme par l'enchantement.*" The fact was—as the Administration had for some time suspected—that the Central Jury was a mere refuge for the rejected candidates of the universities.* Since 1867 the report states that not a single candidate has come before the Central Jury, either for law or medicine, and very few for science or philosophy. In fact, no longer is any attempt made to have examinations at the Central Jury in any faculty except arts or science. In the last report, published in 1872, the three years ending 1870 are included. As a result of all the examinations, 2,701 candidates passed; 287 "with great distinction," and 752 "with distinction;" but, in the Central Jury for free study, only sixty-one candidates passed, none with great distinction, and only ten with distinction. The central examining system, then, apart from regular university training, has practically failed. As the Central Jury was chiefly the resort of "plucked" students, the result is not surprising that, in the triennial report, the figures show the rejection of 60 per cent. of its candidates, while only 32 per cent. were refused by the Academic Juries. I have tried to push the question home, by inquiring of the Belgian authorities what proportion of privately-instructed candidates were successful in obtaining degrees in comparison with university-trained students. but the only reply that I have obtained is—"*Le nombre de ceux qui n'ont fréquenté aucune université est trop minime pour qu'une statistique en fasse mention.*" It will thus be seen that the Belgian system is perfectly conclusive as to efficient graduation being only compatible with a well-ordered curriculum of study. A system founded expressly with the view of giving the freest opening

* This is such an important experience that I quote the words of the Minister of the Interior "La mesure mit en pleine lumière . . . que les récipiendaires formés par des études privées faisaient complètement défaut au jury central, pour le droit et pour la médecine par exemple, et que des inscriptions n'y avaient été prises que par les élèves des quatre universités qui viennent d'être qualifiés."

to private institutions and home studies, has been, in spite of itself, forced more and more into an academic channel, and is now as completely university in its character as the method of graduation followed by the Queen's University in Ireland. It is true that an unacademic door still remains open for candidates, but as they have nearly ceased to enter it, the State may soon be tired of continuing an invitation which the people will not accept. No wonder that Guizot's Commission of 1870, in reporting of the past experience said—"*le système Belge n'a pas donné de bons résultats;*" nor that the distinguished Belgian politician Laveleye thus writes of it:—"The rivalry of these four institutions ought to have produced an intellectual life and activity of a kind most profitable to the progress of knowledge. That happy result has not been attained, because they adopted a detestable system of examination for conferring degrees. Diplomas are granted by mixed juries, composed, in equal proportions, of professors of one state and one free university. The candidates are questioned by these professors under the control of professors from a rival university. Hence it results, to begin with, that the students content themselves with learning their note-books off by heart; next, that the professors, thus controlled by their colleagues, have to conform to a uniform programme, and thus, by degrees, routine stifles initiative and the genuine spirit of research."

We now come to the London University. If it were necessary, I could say much in its favour as a useful and faithful examining board, supplementary to the other universities of the country. It has been put forward as a type for the reconstruction and concentration of other universities; and in that point of view I have a right to show that its past history entirely fails to give us confidence. As an educational machine it is singularly unproductive in comparison with existing universities. Understand the limit of my indictment in this respect. I do not deny that its

lower matriculation examination is successful; for it is good in itself, though too extensive in the demands of subjects; but still it is not beyond adequate preparation, and the proof of this is, that both candidates and undergraduates increase. Like the *Abiturienten Examen* of Germany, it has a useful influence on the schools of the country. Nevertheless, such an examination is the lowest function of a university. The main function of a normal university is to promote the study of higher education in a systematic and regular way, and only to use degrees as a support to its curriculum.

The London University prescribes no curriculum, except in medicine, and has no teaching functions, so it depends upon degrees as its only educational power. It is a university of modern foundation, and hence it would be unfair to test its achievements in its early years; I therefore leave the period from 1838 to 1860 without a close examination, and will chiefly rely on the ten subsequent years. The following points will be considered as fair tests of work:—

1. Is the educational influence of the University of London extending as shown by an increase in the number of its degrees?
2. Is the proportion of degrees to matriculated students increasing or diminishing?
3. Does the number of its degrees stand favourably with that of other universities in the United Kingdom?

It is only by distinct answers to such questions as these that we can find out whether a mere examining university, dissociated from teaching functions, is capable of exerting an important, though indirect, influence on the higher education of a kingdom. It is usual to look at the degrees of Arts—representing, as they do, general culture in a university—as an index of its effect on higher education. I take the three last quinquennial periods of the London University in illustration. In the five years ending 1860, there is an

annual average of sixty-three Bachelors of Arts; in the five years ending 1865 the average is sixty; and in the last period, ending 1870, the average is sixty-five. About ten of these go up annually to the higher degree of M.A. This, then, represents the outcome and want of progression of the London University on the general higher culture of the United Kingdom and of the British Colonies, including India; for the charter of 1849 added these to its province. It is a marked feature in the University of London, that its influence on all forms of higher education now appears to be practically stationary. There is no substantial increase in any one class of its degrees, either in arts, in science, in law, or in medicine.* This is the more remarkable, when we recollect the large increase in its matriculated students, who have risen from 265 in 1861 to 420 in 1870. Both the experience of the Dublin and the London University is against any large expectation of efficient arts training except in organised colleges having a distinct university aim and feeling Trinity College has external students enrolled for degree examinations, but, according to Professor Andrews, less than 30 per cent. of them actually go up for degrees, and not one of them, in the years which he investigated, took a first-class at the degree examination. In the London University exhibitions and gold medals are given at graduation, and these represent the first class of the Dublin and other universities. Since its foundation forty-four of these have been given in mathematics and natural philosophy, of which thirty-eight were taken by Oxford and Cambridge, or by University College men, leaving only six for less collegiate institutions. In the same period twenty-five exhibitions and medals were given for classics, of which,

* In the two quinquennial periods ending 1865 and 1870, the number of graduates, including higher degrees, was respectively—for arts, sixty-nine and seventy-five; for science, twelve and twelve; for law, thirteen and ten, for medicine, thirty-two and thirty-three.

twenty-two were taken by students of Oxford, Cambridge, University College, or King's College, leaving only three for private institutions. The latter were, however, more successful in moral philosophy, logic, and the cognate subjects, for out of thirty-two exhibitions and medals, the private institutions carried off seventeen.

If the influence of the University of London on higher education be progressive, a larger crop of students should, as in all healthy universities, produce a larger crop of degrees; but this is not the case with that examining board, for its old and new degrees now remain stationary, though its enrolled students increase. From 1838 to 1862 four matriculated students produced a new graduate in arts; for the last five years nearly six students are required for that purpose. Nor can it be said that increased severity of examination explains the anomaly, because, during those five years (the only period comparable among its years on account of the institution of new degrees), the number of candidates is as stationary as that of its degrees.* If the standard of degrees be increased, so must the corresponding standard of matriculation; for whereas six candidates previously to 1862 produced five matriculated students, it now requires ten to pass the same number; yet, with these presumably more highly qualified students augmenting in number, the degrees are stagnant. The fact that a smaller proportion of candidates than formerly passes the matriculation examination has another important signification. If a mere examining board suffice to direct the course of superior education in a country, the London University has now had time enough to exercise its influence on the schools which attach themselves to it. yet we find that they have

* From 1866 to 1870 inclusive the candidates at all degree examinations are 615, 610, 649, 620, 631, while the degrees are 158, 131, 127, 128, 131. This period of five years is large in its arts candidates as compared with the preceding five years, 200 as against 158, yet the degrees are only 65 as against 60.

not responded to the demands for higher qualifications; because, though they have sent numerous candidates, these are in a worse state of preparation than formerly, as indicated by their increased proportion of failures. Thus, though matriculation candidates are more numerous, the candidates for degrees do not augment, nor do the graduates substantially increase in number. One thing does increase in a notable degree, and that is the ages of the graduates. If we take the three decennial periods of the operation of the university, this will be apparent: in the first periods, the average age of art graduates was less than twenty-two; in the second it was twenty-two and a half; and in the third it was close on twenty-five years. At this rate of increase, the time may come when the University of London will have to rule, as the Emperor of China has done in regard to its great Chinese prototype, that if a candidate regularly attend all examinations, though without success, till he is eighty years of age, he then becomes a graduate *de jure*. The increase of age is not a good sign. It shows that instead of being for the many, the ambition of the University of London is to become a fancy and a select university for the few. This is the reason why the influence of that university, apart from its matriculation, is so singularly small in comparison with the area which it professes to cover. For the last ten years the average number of all its graduates, scholastic, scientific, legal, and medical, is 130; while the arts degrees alone in the two Irish universities amount to 338; and yet the proposal has been made to reconstruct them on the type of the University of London, which would be to replace an excellent productive machine by a singularly unproductive one—a strange phenomenon in the history of human progress!

The stereotyped answers to all such comparisons are well known. Look to the wide extent of subjects and the difficulty of attainment of the London degrees in comparison

with those of other universities! I refuse to admit either of these reasons, presuming them to be true, as a justification for the small productiveness of a State-supported institution. I admit that a wide extent of subjects, when offered for selection, is a merit; but when it is demanded from each individual, according to the London practice, then it is not so fitted for mental training as the less ambitious plan of the older universities. Any one university may easily raise a fancy standard, and, supported by public funds in the shape of scholarships, exhibitions, and gold medals, make its graduates double-buttoned instead of single-buttoned mandarins, and yet fail in its national purpose. For the object of a university is not merely to have an honour list, but also to promote efficient study among many, as proved by their attaining degrees on fair and reasonable, though adequate conditions. Unless it does that, the general higher education of the country is sacrificed to the glory of a few select graduates.* The London University is fast drifting into this position. Originally it had a useful, well-defined, and carefully-considered position, which it has abandoned in successive charters, and the limitation of its effect on education is, as I think, much due to this abandonment. Now, it has separated itself from all other universities, and has no academic traditions to cling to, except those in China.

There, Examining Boards are constituted, on a like principle, by the State; and the graduates form the aristocracy and bureaucracy of the Empire. Doubtless that system has had an important influence in preserving China in its integrity, outside the rest of the world, but also in holding it back centuries behind the age. The object of the

* This effect is seen in operation at University College, which is the chief preparer for medical degrees. Its first-year medical students average about 90, and its fourth-year about 40. Yet, even of those completing their medical studies, only an average of $4\frac{1}{2}$, or about one-ninth, proceed with their degrees at the University of London, the rest contenting themselves with the licence of the College of Surgeons or Apothecaries' Company.

Examining Boards of China is to suppress the liberties and development of the people by educating them only in ancient traditions and in abject reverence to the ruling powers. It does not do for State purposes that the people should have other sages than Confucius and Mencius, so the five classics confine their knowledge and repress all freedom of thought. China has not often had such an enlightened Emperor as the great Taitsou, who knew how important it was to found and endow teaching colleges, but it has had many Chancellors of the Exchequer who have repressed Government aid to colleges as being dangerous in promoting the growth of individual and intellectual liberty, and who have substituted for them the cramping unity of Examining Boards. The origin of the Chinese system is lost in antiquity; but we ought not to forget that the Byzantine Empire had an organised examining system of much the same character. The graduated schools of the Roman type soon lost their vitality in the Empire of the East; and education, fostered through examination, on a system nearly as organised as that of China, struggled with difficulty to keep the Empire imbued with classical lore. Even women, as instanced in the cases of the Empress Theodosia and the Princess Anna Comnena, graduated in the *trivium* and *quadrivium*. Intellects, so fostered, languished and ultimately died of inanition. Voltaire has described the result with fierce invective; though judgment may be given in the calmer words of Gibbon, who says, "their languid souls seemed alike incapable of thought or action. In the revolution of ten centuries, not a single discovery was made to exalt the dignity or promote the happiness of mankind."

I do not accuse the London University, in its present form and with its existing limitations, of producing a Chinese unity of education. On the contrary, its existence, as a *supplement* to other universities, adds to the variety.

In fact, one of the leading objections which schools urge against this system is, that its degrees have not unity within themselves; that, having no curriculum to guide it, and no teaching functions, its standards are ever varying; that its examinations "*are in the air*," and can only be caught by a flying leap. When the university of London was first founded, the two great English universities had a narrow and monotonous uniformity of examination, and the diversity thus introduced was important. The system of the London University is now proposed, not as an addition to, but as a substitute for, the varying systems of other universities, and educationalists may well be amazed. The recent discourses of Döllinger have shown how precious in the eyes of Germans are the independence and varieties of their universities. These have produced the vigour and breadth of German thought. Though the German universities are supported by the State, they are invariably left in independence, variety both in studies and in examinations being encouraged; the State never attempts to obtain an intellectual unity, which would be as hideous in mental development as it would be in animal organisation. The importance which the North German Confederation attaches to variety of teaching and examination in the universities is well shown by the system of "*Staats Examen*" for medical practitioners. All of them must pass that, as well as the degree examination, before they are allowed to practise. Previously to 1862 the State Examination was held at Berlin or other centres of administration, so that it was quite disconnected with the universities. This was found so damaging to medical education, that the system has been decentralised, and it is now carried out at the separate universities by an Examining Board, partly composed of professors and partly of qualified medical practitioners, the President being an outsider nominated by the Government. The examinations of this Board, though

supplementary to the degree examination, are still pervaded by university influences, which prevent the stereotyping character of a central examining system. The importance of this university connection is obvious. A State professional examination must always aim at a *minimum*, not a *maximum* of knowledge. If the State imitated the University of London, for instance, in demanding a high standard of requirements, it might, like it, get some thirty highly qualified practitioners, but it would leave the ranks of the profession empty. And, if this Examining Board were altogether external to the universities, as formerly was the case in Germany, it creates an overpowering incentive to work only to the minimum and to neglect higher qualifications. Infinitely worse would it be, if this "one portal" system of admission to professions were accessible *before* instead of *after* University graduation. In Germany the State Examination has always been supplementary to, not a substitute for, university graduation.

The old universities of Italy, as long as they were objects of interest and pride to the municipalities, and while their examinations were independent of Church and State, were famous and productive; but when Popes, Kings, Grand Dukes, and little Dukes, tried to reconcile them to a Church standard, by producing unity from diversity, they tumbled into decrepitude.

Want of unity in degrees may indicate different levels of qualifications, which public opinion would soon correct if they fell too low; but it produces a variety in intellectual attainments and modes of thought which are infinitely preferable to a stereotyped system of examination, like that of the Chinese, or even that of the London University, if it were made a type for State adoption. A free country like England will not tolerate State unity in education any more than it has tolerated it in any region of her politics. She has long struggled for individuality in her liberties. A one

monarchical Government, a one Church, a one system of Colonial government, a one classical system of education, have all yielded to diversity; but we are now told that the State ought to bring back universities to a unity. The genius of a free people will prevent it. As despotism consists in forcing one will and opinion upon others, no doubt that principle could easily and insensibly be introduced into the universities, our manufactories of thinkers, by a State uniformity of examination; nothing more easy than to pull men through holes of the same size, after the fashion of manufacturing wires. Our diversity of education does a good deal for us even in trade. England and Germany, with their free universities and diverse thinkers, do much in the spread of freethought. We export annually £650,000 worth of books from this country, and import only £118,000 worth to supply our deficiencies in originality. Cast all our intellects into one mould, or into three moulds, one for each part of the kingdom, and see how long the originality will last. France has managed to do this, and has no many-sidedness in the characters of her people to break up the revolutionary waves produced by the impulse of a class. A man does not live alone for the State; he lives also for himself, and the more complete is his individuality, the better citizen is he likely to become. The French Revolution did not understand this, and raised a Spartan view of the State as the idol for universal worship. Since then, that unhappy country has been visited by many troubles, in punishment for ignoring the fact that each one of its people had an intellect and a soul to develop according to his own individuality, and not according to a State pattern, approved and sealed by a Government authority. The French nation began by worshipping a Greek idol, and have finished by bowing the knee to the Chinese god who presides over common examinations.

In England, as yet, we have too much variety of character

and thought to be subject to revolutionary danger, but our statesmen may manage to change all this. The University of London, though only one of the universities in the kingdom, has already done much to make mental philosophy run in a single channel, because the examinations are not local but universal in their range. No committee or senate is stronger than the strongest man in it; and the London University had a very strong senator in the late Mr. Grote, who gave to it and to the country the most loyal service. He was much interested in, and deeply impressed with, the truth of one particular school of thought, of which my friend Bain, the former examiner, is an eminent professor; and that system has struck its roots deep into those schools which connect themselves with the university. Examiners may be and now are changed, but the senate which appoints them does not vary except by the death of its members, and then is apt to continue its traditions. The evil of sameness attaches both to localised and general universities; but it is reduced to a minimum in the former, because the students circulate and may vary the character of instruction, while in a general examining board it rises to a maximum. Even as regards the physical and natural sciences, the evil has been keenly felt in France. It is far more important, however, in the case of the mental sciences, for they form the moulds into which the opinions of our students are cast. If a general examining university were made a substitute for, instead of a supplement to, other universities, that influence would be intolerable. Watt, when asked what he sold, told the king that he sold power; he never sold so much as the examiner in mental philosophy for the University of London has through his books. The creation and distribution of intellectual power are, it is true, the great objects of higher academic training; and none, in my own humble judgment, is of better quality than that which has emanated from my professional col-

league and friend in Aberdeen ; but the system under which he has spread it does not necessarily provide for power of a good quality, but only for that which suits the taste of one or two men ; and yet it is general, not local, in its application. One great evil of university education, and still more of university examination, is to create faithful disciples rather than independent thinkers. The diversity of teaching in different universities tends to mitigate this evil, but the uniformity of a common system of examination vastly augments it. When the Government takes graduation in hand, and stamps our intellects, as it does its sovereigns, with one uniform die, the power at its disposal will be immense, but, as in France, the intellects will in time be crushed under the stroke, and then will not be worth the coining.

It is now necessary to point out why it is desirable to keep together the teaching and examining functions of universities as of old, and how it is that examinations alone fail to produce a large educational, though, as I have just shown, they do produce a directive effect. A combined university, when well conducted, aims and succeeds at producing an *educated* man ; an Examining Board can only be assured that it has produced a *crammed* man. It is the curriculum of the university, not the examination, which educates the man. Laboulaye, a member of Guizot's Commission of 1870, who visited foreign universities with the view of reforming the University of France, points out how little influence examination by itself has as an educational power. In Austria there are perpetual examinations, but Laboulaye says, " Austria, the very country of examinations, is precisely that where the students do not work." Cramming is not an unmitigated evil, and I defended it in the House as being a reaction against the slow teaching of our classical public schools. When you cram a goose, the food is converted into diseased liver, which is not good for the goose, though it may be for those who live upon it in the

form of Strasburg pies. It is obvious that subjects enjoined by an examination, without any co-ordination through a curriculum, are likely to be introduced by cram. The Examining Board looks only to knowledge, however acquired, as the result; while the real university looks upon it less in that light, and more as a manifestation of the student's successful attention to a prescribed course of study organised for and necessary to his mental discipline and development. In view to this end, the course of instruction is varied, and gradually is strengthened according to the natural evolution of the mental faculties. Strong food like oatmeal is good for Scotchmen and Scotch students, but it is not adapted for babes; and baby-farmers have learned this, for it is the chief means they use for slaughtering the children committed to them, with the view of being put out of the world in the most innocent manner. Like the judicious feeding of the young, the mode of getting and keeping true knowledge is by a process of natural sequence and development; its indiscriminate acquirement is cram. Isolated facts and truths acquired by rote or by cram, unconnected and arranged by educational processes, are like useful objects thrown into a lumber press, forgotten when required, or not to hand when remembered. It is clear that you raise the tendency to cram when you separate the tests of knowledge from the processes of acquiring it. You see that, though in a mitigated form, in Cambridge. There you have seventeen colleges, with an outside university examination. The consequence is that intellectual training has passed away from the professors; while preparation for degrees, which is its substitute, is undertaken by private "coaches," who drive their pupils, not on the high-road of learning, but by those short cuts which lead to the examiner's little paddock; for their art consists in knowing what "is likely to be set," not in inspiring a love of knowledge for its own sake. Colleges

ought not to be separate from, but should be integral parts of a university, and then they will become what Pattison wishes, healthy organs of a common organisation. When examinations are used as a test of acquired information, instead of as an evidence of a course of mental training, a good memory will always have an advantage over a thoughtful and trained intellect with less retentive power as to existing knowledge. The Chinese are forced to acknowledge that this is a result of their separate examining systems, and they honestly give large credit to it, as when they force every candidate to write out from memory the whole of the sacred Edict of the Emperor Kanghi. Such a feat of memory is as useless as that of Xerxes when he learned by heart the names of a hundred thousand soldiers. Pascal has told us that Epictetus and Montaigne should always be read as correctives of each other, so, as I have already quoted the Phrygian philosopher, I may remind you of an opposite saying of the old French essayist, "*Sçavoir par cœur n'est pas sçavoir.*" It is true that memory is essential in education, as it is in cram, but, in the first case, it is only one of several intellectual faculties which are simultaneously developed, while, in the second, it is chiefly relied on to obtain a result that, at the best, is only a sham representation of undeveloped faculties. The one method resembles that of the prudent trainer for a boat-race, when he carefully trains all parts of the body, and not merely those which are to be brought into play in the race; the other is the system of the unskilful trainer who presses the muscles into over-action, and damages the heart for life.

A university, fulfilling its purpose to the nation, is, or ought to be, something far higher and far more useful than even a combined teaching and degree-conferring institution. It ought to be one of the great intellectual treasuries of the nation, always stored to the full with the richest learning; it ought, through its educative functions, to be the distributor

of that wealth to those who can use it well; and it ought in itself to be productive and creative of new treasures of science and literature by the researches of its Professors. None of our universities in the United Kingdom are, to the full extent, what they might and should be in these three points; many in Germany have become so during the last half-century. Their union is perfectly compatible with teaching. "The greatest advances," says John Stuart Mill, "which have been made in the various sciences, both moral and physical, have originated with those who were public teachers of them: from Plato and Aristotle, to the great names of the Scotch, French, and German universities."

A smaller conception than I have given is unworthy of a university in the present age. It is this conception that has made Germany great in the last half-century; it is the want of that conception which has made France little. You may have teaching institutions, technical schools, examining boards, and institutes for the advance of science and literature, but not one of these forms a university. Only when they are united by a common organisation, mutually supporting each other, each efficient organs of a common body, that the idea of a university is complete, or the possibility of large results attainable.

The great objection, in the mind of Mr. Lowe and others, to the present union of tuition and examination is, that the professors have a preponderating influence in the appraisement of the results of their own labours. He would not even have the examiners selected from the *genus* teacher, for he states, "I do not presume to say that the very same men examine students who have had the teaching of those students, but they are men of the same class, of the same *esprit de corps.*" He alludes, in that passage, to Oxford and Cambridge, but he would still more condemn the Scotch system, in which the actual professors, associated with extra-academical assessors, are the examiners. I do

not say that we do not need reform in Scotland in this respect, for I think the proportion of the latter to the former is still too small; and most willingly would we increase them, but we possess no further funds for their payment. Still, in principle, I think the combination of professorial and extra-academical examiners is a most excellent system. It is essential to the diversity of university teaching and university degrees; and I have already shown of what national importance that is. I do not believe that it leads to any favouritism or lightness in examinations, at least, during ten years' experience as an examiner, I never met a single case in which the extra-academical assessors have complained of the leniency of the examinations, although I have seen instances, both with myself and others, where they have remonstrated with us for our severity. This naturally arises from the circumstance that the professorial examiner is always fresh in the whole subjects of his course, while the outside examiner, if not himself a teacher, can only possess a general acquaintance with them. I do not think Mr. Lowe can have meant, what his reported words imply, that teachers, as a class, should not be examiners, or I would lay down the contrary proposition with great breadth, that no one but teachers can be good examiners. Even in the *Abiturienten Examen* of Germany, the questions are selected by the Board from those sent in by teachers of the schools for approval. In the University of London the examiners are chiefly teachers; in its prototype, the Chinese Examining Board, the college professors are associated with the Examining Mandarins; in the Belgian graduation system, university professors examine university students, and, associated with private professors, form the Central Examining Board for private students. In the Queen's University in Ireland, the professors are the examiners, and, in the medical degrees, are associated with extra-academical examiners. In the German Universities, and, in fact, nearly all over Europe, the same conditions of

examination prevail. All that I think Mr. Lowe can have meant is, that teachers should not examine their own pupils, and I would assent to this view if it were limited to the proposition that they should not do so without the presence and assistance of extra-academical examiners. I would be inclined to go further, and open the oral examinations to the public, to give the most ample evidence of their fairness and impartiality. If the views I have put before you of the national importance of keeping up complete diversity among our universities be true, it would be far better for the interests of education to abolish degrees altogether, than to blow them, like a pint bottle in a mould, into a single shape through a common examination. Diversity in graduation is impossible, unless the teachers, who produce variety by their peculiarities of thought, can impress it on the degree as well as on the teaching.*

Far be it from me to say that our Scotch universities do not require improvements, or that they fear the touch of the prudent reformer. In my own day, twice have they been the subject of inquiry by Royal Commissioners, and have accepted the reforms urged upon them without hesitation, and with gratitude. These reforms have been in consonance with their national character, and had for their purpose development, and not revolution. The Act of Parliament that gave power to the Royal Commission which reported in 1863, enjoined the Commissioners to inquire as to the expediency of converting the four universities of Scotland into colleges, and of joining their examining powers into one common Examining Board. The deliverance of the Royal Commission was as follows:—" . . . . It is impossible

* It is to me no demerit that the University of London employs teachers as examiners. From 1861 to 1871 inclusive, there have been 47 medical examiners, of whom 39, or 83 per cent., were teachers in medical schools—34 examiners, or 72 per cent., being from schools in London, which give more than four-fifths of the candidates. So that actually these London examiners are teachers examining their own pupils. In my eyes this is no evil, but stones should not be cast out of a glass house.

for us to report that such a measure would be practicable, and our own deliberations have led us to the conclusion that it would not be expedient. After the most careful consideration, we are unable to see that any important corresponding advantage is likely to be derived from so serious a step as is implied in reducing the ancient universities of Scotland from the position of universities, and converting them into colleges of a new National university." This, I think, you will now admit, was a wise report. Improve our universities as you like—let the full light of day into all their proceedings—but do not lightly alter the fundamental constitution of those universities which have done so much to stamp the national character of Scotland, and which have added so largely to the material prosperity of the whole kingdom.

The immediate object of Mr. Lowe's speech, as I believe, is Ireland, not Scotland. The Irish Roman Catholics claim increased facilities for university instruction. If it were the habit of the Irish poorer classes to frequent universities, the numbers of them actually in collegiate attendance would be unsatisfactory. This is a peculiarity of Scotland, and is not found either in England or Ireland. At Trinity College, for instance, out of 1,390 students who matriculated in the five years ending 1872, there were only 37 "tradesmen and artisans," or little more than 2½ per cent. As is well known, the bulk of university students, in these two countries, come from landowners, professional men, and wealthy merchants and manufacturers; and comparatively few come from the lower portion of the middle classes.* In the following

* In the five years ending 1872 there were 1,390 matriculated students at Trinity College, the occupations of their fathers being as follows :—

Gentlemen	280
Professional Classes	643
Merchants and Manufacturers	169
Stipendiary Magistrates and Civil Service	55
Farmers	70
Agents and Overseers	31
Tradesmen and Artisans	37
Miscellaneous and unreturned	105
	1,390

Irish return of the two former classes, the Roman Catholic priests are excluded, because they have no families to send to universities, and the religious profession of merchants and manufacturers is unknown to me.

	Protestants.	Roman Catholics.
Landowners having more than 100 acres	10,000	2,500
Barristers and Attorneys	1,750	890
Physicians and Surgeons	1,597	751
Apothecaries	209	210
Clergy	3,264	—
Other learned occupations	708	358
	17,528	4,709

The proportion of the main bulk of the university-sending classes in Ireland is therefore, as regards religions, nearly four Protestants to one Roman Catholic; and as the students in actual attendance at the colleges are about 1,200 Protestants to 300 Roman Catholics, the result is what might have been anticipated.* With these facts before us, ought we to revolutionise the university system of Ireland, which is now producing excellent results, to gratify a doubtful demand? Is there any evidence whatever that, in the present condition of Ireland, a large accession of lay Roman Catholic students will be gained by the universities? If there be such a demand, why do they not go to the Roman Catholic University? That has already received the sanction of the Pope, and, therefore, in the eyes of the Church, it is as much a university as if it had a Royal Charter. Students go to its halls in remarkably scanty numbers. I do not deny that there are upwards of a thousand young men in Ireland training for the Roman Catholic priesthood, to whom it

* This proportion is only approximately true for all students, but it is strictly true as regards lay students. The lay students attending Trinity College and the Queen's Colleges amount to 1,360, of whom 1,091 are Protestants and 269 Roman Catholics. Besides these, there are 240 Episcopalians and 63 Presbyterians preparing for the ministry.

would be desirable to extend the benefits of a liberal education. As long as their Church refuses for them a mixed education, and keeps them apart, as a principle of their training, it is impossible to reconcile a free teaching university system with their wants. In the future an increased lay demand may be beyond the capabilities of the existing university system in Ireland; but of that the signs are not apparent. Reforms in the Irish universities require mature consideration, for, in their present state, they are active both in teaching and graduation. In Oxford and Cambridge one graduate is found annually to every five students in attendance; in the Scotch universities one to every seven; in the Irish universities one to every three and a half; and in the London University, if we take four years of matriculation as representing the students, one to every eleven. The Irish universities, therefore, stand highest in relation to graduation. In their influence on the general population, they stand in an intermediate position to England and Scotland: for Scotland has one student to 860 of the population, Ireland one to 2,700, and England one to 4,020.

I have now finished, and I hope I have given good reasons for my belief that nothing would be more injurious to higher education than limiting the diversities of universities by the uniform action of examining boards established under the authority of the State. Far better would it be to use that power to suppress altogether the system of conferring recognised degrees. Such an exercise of power would still leave unfettered the individual development of intellectual thought. The imposition of uniform examinations, in every case where it has been tried, has not only restricted intellectual liberty, but ultimately has produced a mental paralysis in the nation which adopted it.

It has been necessary for me to enter into much illustration and proof of the ruinous effects which follow the destruction of the autonomy of separate universities, by schemes

of common examinations, and I have not had time to follow Mr. Lowe into his view that as "teaching is a trade, it should be arranged as a trade," and consequently, that Government should have nothing to do with the support of that teaching, at least in regard to higher instruction. No doubt he could quote high authority in his support, for Adam Smith, Dunoyer, Herbert Spencer, and others, have argued in the same sense. There are other great thinkers who have maintained, with much vigour the contrary conclusion, by showing that it is the duty of the State to foster those higher studies for which there is not a sufficient demand on the part of those occupied with the affairs of life. Sanscrit and Quaternions may not be in such demand as potatoes and cabbages, and still their study may be important for the advancement of learning. When we find that wise men, like Bacon, Hobbes, Berkeley, Locke, Kant, and Mill, take an opposite view of the duties of the State, we may feel sure that the question will not be hastily decided. Adam Smith was wise when he pointed out that excessive endowments are dangerous to the activity of universities, though Plato was wiser when he saw that two causes, instead of one cause, are in operation in all such cases. You recollect his illustration of the potter in the fourth Book of the "Republic." When the potter becomes too wealthy, he is apt to be indolent and careless, and then he deteriorates in his art. A potter, on the other hand, may be too poor to buy proper tools or instruments, and in that case he not only does his work badly, but he is sure not to teach his sons and apprentices equally well with the potter who is well provided with the implements of his craft. If the first condition form the reason why the great English universities have not done work equal to their resources, the second is undoubtedly the explanation why the Scotch universities are not so productive as they desire to be.

UNIVERSITIES

IN THEIR RELATION TO

PROFESSIONAL EDUCATION.

Address to St. Andrew's Graduates' Association,
8th February, 1873.

THE subject of my address is the position which Universities should occupy in relation to Professional Education. It has recently been the custom to state, especially in debates on the Queen's Colleges in Ireland, that universities ought not to be places for professional instruction, and that, however numerous students for professions may be, the success of colleges should not be measured by them, but only by such students as pass through the curriculum of the faculty of arts. This assertion is made in total ignorance of the origin of universities, and of their duties as instructors of all who have occasion for learning, and not merely of the wealthier classes of society. The older universities did not spring from kings or popes, but had their origin deep down among the professional classes. The latter wished to glorify their professions by raising them above mere empiricism. This could only be done by rationalising and generalising the facts gathered by experience. Hence universities could not spring into being with a completed organisation, panoplied in their armour, as Minerva did out of the brain of Jupiter. At first they were mere schools, which slowly developed into an academical form; for it was not till the twelfth or thirteenth century that they assumed their present university state. Salerno is one of the most ancient and illustrative instances of this development. We

do not know how long a medical school flourished at Salerno, though there is evidence of its existence in the tenth century. In the middle of the eleventh century Monk Rodulf visited it, and what is curious, in its relation to female education, found no one so learned as himself, except a learned lady. Salerno was even then a well-known school of ancient date, for it is described "in urbe Salernitana ubi maximæ medicorum scholæ ab antiquo tempore haberent."* It was a century later, or in 1140, that Roger, first King of Sicily and Naples, directed his attention to Salerno, and gave legal force to its own consuetudinary statutes.† His grandson, the Emperor Frederick II., in 1231, threw a net over the school, for he assumed power to give a State impress to Salernian medical degrees. This seems to have been the origin of the claim made by the State to secure the qualifications of medical practitioners; and, though his statutes were abrogated by Queen Joanna in 1365, it is interesting to know what they were. The Roman Emperor claimed a sort of *veto* over the graduations of Salerno and Naples, because he ordered the graduates who had passed the *magistri* of these schools to come "before ourselves, or, in case of our absence from this realm, before our vicegerent, and receive from him a licence to practise." Except that there does not appear to have been an examination, this practice is identical in theory with the *Staats Examen* of the German States. Both are radically different from the "one-portal" system which has been advocated in this country, and regarding which I shall have a good deal to say hereafter. At present our point of attention is that the old universities arose out of the needs of professions; that in their development they acquired consuetudinary rights, which the State subsequently made

* Quoted by Bulæus, "Hist. Univ. Parisiensis," i. 478.

† Ackermann, "Regimen Sanitatis Salerni," 1776, p. 42; see also Giannone, "Istoria Civile del Regno di Napoli," i., p. 188.

statutory, and finally controlled. As Salerno arose out of medicine, so did Bologna arise out of law. Round the law school of Bologna other professional schools gradually clustered, until it assumed a university form in the middle of the twelfth century. Even beyond 1360 the separate professional schools maintained their independence, and granted their degrees; for there were actually four degree-conferring universities at Bologna—two for law, one for medicine and philosophy, and one for theology.

The University of Paris had its origin in a school of theology, though subsequently becoming remarkable for its philosophy, it attracted a large number of students of all ages. Faculties of medicine and law then grouped themselves around the original theological schola. When provincial universities arose in France, they sometimes took up a single profession, and even now we find this tradition preserved, as a survival, in the separate provincial faculties for medicine, law, and science, which still exist in France. For the *Studium generale* of the old universities did not mean that all studies were taught, but only that certain studies were taught to all. It was only after universities had grown into importance, that popes or kings threw the mantles of the Church or State over them; but they did not attempt to lessen their position as places for professional training. The newer universities were founded by royal charters or papal bulls, and generally included faculties for philosophy, theology, law, and medicine; though not always, as instanced in the migratory university for theology and canon law founded by Innocent IV., or the partial universities of Altdorf, Rostock, Bamberg, and Gratz. Sometimes, as in St. Andrew's, the faculty of arts was external to the professional faculties, and even extramural in position; for then it was a mere pedagogium, or preparatory school for the professional system. It is difficult to say how soon the arts teaching became on a level with the other faculties. In the Univer-

sity of Paris the higher and lower classes of instruction seem to have run together, for children as well as youths were among the *cives* of the university. Thus we find a curious old statute of the University of Paris enjoining all students to refrain from passing through the faculty of arts till they were twelve years of age. This mixture of ages produced strange results, as instanced in the flogging of Bacon at Cambridge, when a mere boy, and of Ignatius Loyola at Paris, when thirty years of age. In the thirteenth century the same mixture of men, youths, and children, was found in the English universities; even then, the faculty of art was rising in importance, as we see in the conflicts between the realists and nominalists, although they had not the dimensions which they assumed under Duns Scotus in the beginning of the fourteenth century. That struggle was like the one now impending, for the realists wished to travel by the *Via antiqua*, and the nominalists by the *Via moderna*. It is very likely that, at Oxford and Cambridge, the importance of the faculty of arts asserted itself sooner than in other universities. It is true that civil law was taught by Vicarius in the middle of the twelfth century at Oxford, along with canon law and theology, and soon after with medicine, but the philosophical faculty very soon emerged into importance. Ultimately, professional teaching at Oxford and Cambridge became subordinate to teaching in arts, which is now looked on as the end, instead of as the beginning, of university life. Recollect that this is a peculiarity confined to our great English universities. As you are aware, they have almost wholly let slip the main object for which universities were founded —to liberalise the professions—while instruction in arts has become their chief end. Hence also they lost their hold on the people, as a whole, and became the universities of the rich. That was not the case in their early days, when poor scholars begged from monastery to monastery till they reached the seats of learning from all parts of the kingdom;

nor was it so even when Bishop Latimer was an undergraduate, for he tells us that many yeomen were among his fellow students. Though Oxford and Cambridge have thus exaggerated the importance of the faculty of arts by making its degrees and honours the end instead of the beginning of university life, the very existence of such a faculty is the foundation and justification for professional training in universities. It is the power of liberalising the professions that distinguishes universities from technical schools. The latter are too apt to look to the more practical ends of professional life, while the former bestow more attention to the scientific foundations on which practice should always be built. The importance of infusing liberal culture into medicine has induced our medical legislators, within the last few years, to insist on a preliminary examination of students before they begin their medical studies. Notwithstanding this, how seldom do we find the seal of the faculty of arts impressed upon medical graduates! In Dublin University an M.D. must be a graduate in arts, but in the Queen's University, and in the Scotch universities, the possession of such graduation is the exception and not the rule. Let us carefully examine into this rarity of methodical academic training among our professional men. In the early constitutions of our universities, the faculty of arts was the preparatory pedagogium of the priest, the lawyer, and the doctor. The subjects embraced in it were selected for their use. At that time the common language of the learned classes was Latin, in which they thought, spoke, and wrote. All the professional treatises were written in the language of Rome. When Descartes wrote in French his famous work on Method, the innovation was thought so great that it was at once translated into Latin. In Scotland, Dr. Gregory was the *Ultimus Romanorum*, as he had to apologise for writing in Latin, a language which his professional brethren had nearly ceased to understand. Classical instruction,

until then, was necessarily made the basis of educational training. In itself it was a renaissance, and was at the same time a revolution of the scholastic system of education, which still feebly struggled on till the Reformation. The scholastic system was long supported by its subservience to theology, "philosophia theologiæ ancilla." It was then that the Protestant universities renounced the necessity of an arts degree for study in the professional faculties, because the controversies of the scholastic system were so unprofitable. Classics replaced it; and Latin orations and Latin composition became as necessary to professional men of former times, as English speaking and composition are to those who practise at the present day. Our Latin and Greek education still goes on, though, for its practical uses, it is as much a survival as the two buttons behind our coats are survivals of the time when the slits and flaps of our ancestral coats had to be buttoned away. Their existence survives their utility. Medical men no longer write or speak Latin, and yet a fourth of a professional man's life is spent in the venerable deception that it is indispensable to him. In fact the only thing that is left of it is that queer survival of writing prescriptions in an abbreviated mongrel Latinity. So the professional man, after spending a fourth of his life at school in learning that which he little uses in after-life, naturally has little disposition to go through a further course of it in the faculty of arts of a university. Yet the latter still runs slowly on the old and worn-out grooves of a system originally framed to aid the professions, though these now run along new courses altogether. The advocates of the old classical system of education only claim for it an indirect utility as a means of culture. If liberal culture be, as it should be, a part of professional training, then the culture should be made to bear directly on the training, and not remain a mere survival of an educational condition that is only known to us in history.

New professions are arising, and for these our old universities make no provisions; old professions have completely changed their aspects, yet the schools and colleges remain as of old. Perhaps the most robust men of our time have been our engineers and mechanicians, for they have given more impulse to civilisation than any other class of men. I look in vain for a single representative man among our Telfords, Watts, Stephensons, Arkwrights, Wedgwoods, whose intellect was nurtured on ancient classical learning, or who could find anything in school life to aid the development of their genius. I look in vain among our scientific heroes—among our Newtons, Daltons, Youngs, Davys, Brewsters, Faradays—for one who owed the cultivation of his intellect to classical education, or who did not push aside the school learning afforded to him as a heavy weight on his mental development. I turn to our medical discoverers, who were obliged to take a classical education, and how difficult do we find it to select one with even a respectable knowledge of classics! Harvey was a B.A.; but, among our Jenners, Hunters, Cullens, and Bells, I do not recollect another instance. And yet our Prime Minister, Mr. Gladstone, and Home Secretary, Mr. Bruce, make orations on the same day, telling us that the old classical system is that which is best fitted for mental culture, under all conditions. That it is so for the culture of statesmen is most probable, for they have to deal with men, rather than with things. That it is the most suitable for priests or for lawyers, I would admit with a great deal more reserve. I know that Scotch lawyers do not care to take our degree of M.A., and ask us to make another degree more suitable to them; but I am glad to say that our Scotch theologians commonly graduate in arts. The fact is that all professions have reached a stage when a single curriculum for an arts degree is neither possible nor tolerable for them, if universities intend to

maintain their chief function of liberalising the professions. You must not judge of other universities by Oxford and Cambridge, for they are exceptional. The old English universities have not the same function as the Scotch and Irish universities. The former teach men how to spend a thousand a year with dignity and intelligence, while the latter aim at showing men how to make a thousand a year under the same conditions. The first two attract the rich, and can only secure the poor by paying for their attendance; for it is a remarkable fact, according to Mr. Mark Pattison, that one out of every three students at Oxford is paid, by means of a scholarship, to attend its instructional classes. Even our popular universities, which still give prominence to professional degrees, have a poor outcome of graduates in arts. Let us compare them in proportion to students in annual attendance, and this will be at once apparent. In the Irish universities there is one degree in arts to every six students; while in Scotland there is only one to thirty students, and in the London University there is one to twenty-four. This is, no doubt, owing to the circumstance that the Scotch universities exaggerated as much in one direction their teaching functions, as the English Universities exaggerated in another direction their examining functions. It is due also to the fact that the revival of the practice of taking degrees in arts by examination, which arose in the English universities at the beginning of this century, only commenced in the Scotch universities thirty years later; and still more to the circumstance that the latter were at an early period, and are now, so largely occupied with professional teaching. In a true academic system, teaching and examining functions should be held in an even balance. This also shows that, in the struggle for professional existence, there is little time to go aside for a degree in the faculty of arts according to its present curriculum. Professional training begins at

seventeen or eighteen years of age, before an arts degree is attainable. Though society refuse to adapt itself to the ancient liberal curriculum of a university, is it unreasonable to expect that the latter should adapt itself to society? or, in other words, instead of the liberal curriculum being a mere survival of a preparation for professions which have advanced with science, and left it behind, might they not go on *pari passu?* Universities cannot accomplish this by simply heaping up new subjects on an overloaded curriculum; for, in this way, study in arts and the requirements of an active profession, ever developing by discoveries in science, can never be made compatible. The curriculum must not be uniform for all professions; it should be made to adjust itself to their several requirements. Universities can no longer stand on their ancient dignity, and refuse even to consider such adjustments. The demand, as I have expressed it, is not one of a few half-educated radical reformers. It is the demand of a changed civilisation, which has resulted from three main causes. These are, the rapid advance of science and its numerous applications to industrial life; the free and constant intercommunication of peoples; and the liberalisation of political institutions. It is true that these causes have been long in operation on nations, but they have produced a singularly accelerated effect in the last half-century. The youth of our country cannot chain itself to the past, and see the modern stream of thought and action flow swiftly past them. Unless our universities go with the stream, by fitting themselves to the changed requirements of modern society, need they be astonished if society soon get accustomed to look upon them as venerable monuments of a past age?

You cannot suppose that I could stand before my fellow graduates, who have honoured me by election as their representative for two ancient universities, and advocate the study of professions shorn of their liberal culture. Mental culture

is the mother of science. Without mental culture mere scientific and professional training becomes narrow and unproductive. As the mother teaches her progeny to speak, so does literature teach science to be articulate in the expression of her thoughts, and to bring them into relations with human progress and human desires. It is because I feel that liberal culture is not only necessary to adorn, but ought to be the foundation of all professions, that I advocate the necessity of bringing the universities and the professions into a harmony which once existed, but is now replaced by discord. My object is to see universities assume their old function of being the great liberalising power of the professions. Every profession is now vastly more extended in its knowledge and requirements than it was when universities were first founded; yet life is little longer than it was among our ancestors. The skull of a man is a close and rigid cavity, which can only hold an average quantity of brains; it is not a vulcanised indiarubber bag, capable of swelling out at each pressure applied to it. We must put into this space of fixed dimensions a continually growing quantity of knowledge; and you cannot be astonished if you find a disposition to reject that which is useless for that which is useful. Liberal culture is not only useful but indispensable; only the same kind of crop is not suited for food under all conditions. If our professions reconcile themselves to our faculties of arts, the latter must first adjust a variable curriculum to the wants of the former. In the active competition of the world, men cannot afford to spend their life up to twenty-one or twenty-two years of age in the study of a preparatory degree which is to be the mere foundation-stone of their professional edifice. The difficulty might be met by making the M.A. degree a real step only attainable by a high educational standard; while the lower degree of bachelor—the *bas chevalier* or inferior knight—ought to be reached not by one road only, but by various converging

roads, suitable to the varying kinds of knowledge required by different professions. They might thus be induced now, as in past times, to resort to the faculty of arts for its seal of liberal culture. Look at the struggles of the doctors, the lawyers, and the clergy, to get, in all sorts of strange fashions, the suitable culture which the universities deny them, except under conditions that are inconsistent with their professional life. The clergy in England become "literates" in institutions which are cheaper and more accessible than the universities. Medical men have to undergo a preliminary literary examination before commencing their professional studies: and lawyers are constituting new standards of study at their inns, or requiring them before admitting men on the roll of attorneys or solicitors. The divorce between the professions and the older universities will soon be complete; and the gap is widening between them and the arts faculties of the Scotch and Irish universities. Why do the universities not study the nature of the culture expressed by these preliminary literary examinations, and offer the degree of B.A. to those who pass them with a thorough and satisfactory knowledge? That lower degree may not include everything, though it may include much. If the medical profession insist upon having a modern language, or English literature—something of Latin, and more or perhaps all of Greek, may have to yield to the new requirement. The preliminary examination for medical students in the Scotch universities includes five compulsory subjects, viz.:—English, Latin, arithmetic, lower mathematics, and mechanics; but the M.B. must take two and the M.D. three of the following optional subjects, viz.:—French, German, Greek, higher mathematics, natural philosophy, logic, moral philosophy. Surely this range of subjects is wide enough for a lower degree in arts. High literary culture is not confined to the glorious classical relics of ancient Rome and Athens. In Italy, France, and Germany,

there are illustrious authors in recent times. Surely a university must be hard to satisfy, if it cannot extract the graces of polite literature from such modern authors. The inductive, deductive, and perceptive faculties of professional men might assuredly be developed and strengthened by mental and physical science without necessarily going back to the days of Plato and Aristotle. Such sciences might serve them better in the struggle of professional existence than the Satires of Juvenal, the Odes of Horace, or the "Republic" of Plato. New co-ordinations of knowledge, certified by a literary degree, would win back the professions to an organised curriculum of a liberal culture compatible with the active callings in life represented in modern society. In thus recommending an opening up of various roads converging on the minor degree of B.A., I am an advocate for liberal culture, which is now becoming, so far as our universities are concerned, more and more rare among professional men.

Although I have more hope that the Scotch and Irish universities will sooner adapt their liberal culture to the professions than the old English universities, still there are many signs that Oxford and Cambridge are alive to the necessity of specialising the studies for degrees, and of not confining them to a single curriculum. This tendency is apparent in the various schools from which honours may be obtained. The pass examination for B.A. in the English universities satisfies 70 per cent. of its students, and yet has no more intellectual significance than the title of Esquire has a distinct social value. Under altered circumstances, as a preparation for professional life, it might not mean, as it certainly does not now mean, a thorough grounding in the seven arts, but it might denote a thoroughness in preparation for those limited subjects of liberal culture which lie at the basis of each profession. If Oxford and Cambridge made its M.A. an honour degree, open only

to scholarly attainments, and its B.A. a lower degree indicating efficient preparation for professional study, or even for manufacturing industry, they would not only bring themselves into better harmony with the professions, but would also improve their relations with the secondary schools which now scarcely send a fifth of their whole number for university training. These, under the pressure of parents, are now rapidly introducing modern subjects into their schemes of instruction.

The monopolists of our faculties of arts may characterise such proposals as revolutionary; but the public, in whose interests they are conceived, know that they are only divisions of mental labour, rendered inevitable by the progress of society. Revolution is an ugly word, though it applies to education as well as to politics. The educational system of Plato has now no existence, and is only interesting in history. The old methods of teaching through dialectics answered well for centuries, although they are now as extinct as mammoths. Afterwards the scholastic system did the world good service, and then wore itself out. Our exclusive system of classical education has had its day, and must be content to see new educational co-ordinations, in which it may sometimes have to assume a subordinate position. The wisest of books tells us that, though we should stand upon the ancient way, we should look about us and discover what is the straight and right way, and so walk in it. I have shown you that the ancient way in education was for universities to make their arts curriculum a careful propædeutic, or course of mental preparation for the professions; and the straight and right way is for them to adjust it to the professions as they are in modern times, and not as they were in ancient times.

As the professions found university training unfit as a propædeutic, they began to create special schools—schools of medicine, engineering, architecture, navigation—alto-

gether outside the universities. Sometimes these technical schools, as at Zurich and Paris, have altogether dwarfed the university systems. I am not likely to be thought an enemy to technical education, for I have long directed attention to the deficiencies of technological instruction in this country. I have, at the same time, been chary in recommending the establishment of special schools, unless strong grounds exist, as illustrated in the Indian College for Civil Engineering, and in the School for Navigation at Greenwich, for giving to them a character of practical training such as the universities are not at present prepared to afford. Such special schools may produce length, but they cannot produce breadth, in education. They look only to one subject and its applications; they focus the light, as it were, on a particular spot, and illumine that brightly, but they thus intensify the darkness all around. Unluckily the universities allowed profession after profession to slip away from them, because they could not escape from their mediæval traditions. Nothing is more strange, for instance, than their abandonment of the teaching profession, which was of their own creation, while the older professions were rather the creators of the universities. Originally graduates were not only empowered, but they were compelled, to be teachers. The graduation was the diploma of a teacher; yet the universities have allowed independent normal schools for the training of teachers to grow up around them. The Education Act, especially that for Scotland, obviously contemplates that the universities will resume their ancient functions of training teachers, for it agrees to accept a university degree as equivalent to a special examination in all subjects covered by it. A little adaptation of the arts degree would, in fact, include everything which the State demands from the teachers of a public school, except practice in teaching and in music. If, then, the universities choose to adapt their lower degrees to the

vocation of the elementary teacher, and to found a higher pedagogic degree, they may soon place themselves in harmony with that profession which originally was of their own creation. I look with confidence to the time when the State will use universities instead of normal schools, as means of producing public teachers, and when special degrees for teachers will induce men who enter into the teaching profession to assume that occupation with those sureties of qualifications which are now given by other recognised professions in which the public have an interest.

I have always lived in the hope of seeing our universities resume their old function of liberalising the professions. It has, therefore, been a source of pride and gratification to me to see my own University of Edinburgh developing courses of engineering and agriculture, and opening its degrees to industrial professions. It is only by thus developing professional instruction in connection with general culture that you can hope to remedy the exclusiveness and narrowness with which all professions are apt to be surrounded. Suppose, for instance, that there were as distinct colleges for painting and sculpture as there are for medicine, how soon would the study of nature, in its wonderful varieties, be cramped and crippled by the conventionalism of the professors! Schools of drawing and modelling are, of course, necessary, but a college of these subjects would be detrimental to the fine arts. Hence it is wise to connect fine arts professorships with the universities, because the artist depends for the grace of his creations, far more on his cultured perceptions, than on any manipulative dexterity of his brush or chisel.

In medicine, special schools have grown numerous, because Oxford and Cambridge neglected their duties as liberalisers and cultivators of professions. Though rivers will not flow back to the sources whence they came, yet, in the future, the sources may supply healthier waters to

the streams than they have done in past times. So our English universities, though they have lost their hold on the medical profession, may at least adjust a preparatory curriculum to suit it, and thus secure to medical students a liberal culture bearing on their future life before they begin their purely professional training.

Universities should understand that, if they desire society to uphold their ancient academic rights, they must show themselves willing to extend modern obligations to society.

I do not presume to give detailed schemes for the construction of the various academic roads which might lead through the faculty of arts to the professional faculties. Each of these would be the best adviser how the several roads should be constructed. All I venture to press is, that the roads should be sufficiently numerous not only to lead to recognised academic professions, but also to the great occupations of manufacturing and mercantile industries, which above all require to be mellowed by liberal culture.

As I have now the honour of addressing an audience chiefly composed of the medical profession, allow me to explain the attitude of hesitation, if not of opposition, which the Scotch universities have taken up in reference to a general and popular cry for a "one-portal" system of examination. This demand has arisen from a just discontent with the laxity of examination on the part of some of the nineteen licensing bodies in the United Kingdom. It is contended that a single State examination would give better security for the qualifications of medical men than the separate licensing systems. No one can dispute the right of the State to fix its own standard of qualifications for licences involving civil rights and affecting the health of its citizens. That right, as I have shown, was exercised as early as the thirteenth century, and it now receives full expression in the *Staats Examen* of Germany. That, both

in its former and present state, is a very different thing from the one-portal system which has been proposed for this country. In Germany the State examination was always supplementary to the academic curriculum. It was simply a State door, through which the university-trained student had to pass before he assumed civil rights of practice. The one-portal system proposed for this country might be anterior to university or corporate graduation, so that the State licence would be, instead of a supplement, a substitute for academic graduation. Any single licensing system must aim at a minimum and not at a maximum standard of qualifications. Suppose it aimed at a maximum, like the University of London, what would follow? Necessarily the ranks of the profession must remain empty. Under such a system the demand for medical men could not be supplied, and the public would suffer. The one-portal system can only prevent a man from passing in under a minimum standard, but it cannot insure higher qualifications. Yet such a minimum plan of licensing would govern the whole medical schools of the country, as surely as the main motive wheel in a factory governs the motions of a thousand bobbins.

Under such circumstances, the ornamental degrees of universities and corporations would have no more influence on medical education, as a whole, than the brightly polished brass-work on the standard of an engine has upon its motive power. The qualifications of medical men would then be exactly what the minimum involved, and, except rarely, would be no higher. For all experience teaches us that the great bulk of students, with a compulsory examination before them, concentrate their vision on that alone, and refuse to look beyond it. So that teaching schools and universities must then teach down to this minimum, and not teach up to their maximum, if they are to preserve their students from mere crammers. It is this that has rendered uniform standards of examination so fatal to intellectual develop-

ment in every country where they have been tried. It is this that has made Germany abandon its old centralised system of State examination; for it is now carried on at the seat of each university, chiefly by the professors and partly by assessors appointed by the State. Even in this modified form it has much injured medical graduation, because students work for the essential licence and neglect the mere academic honours. Germany is the typical country of universities, for it counts twenty-four of them, and these contain 20,000 matriculated students. Its principle is to give to each university a separate autonomy and the utmost liberty of teaching and examination. It preserves for the State a right of proof that these functions have been discharged efficiently when civil rights are conferred; but it carefully makes the exercise of this right a mere supplement to a well-ordered university curriculum.* This is well

* In a letter to me, dated 8th February, 1873, Baron Liebig, President of the Bavarian Academy of Sciences, thus describes the action of the German system.—"We require that the physician, before he practises, should prove his capability and knowledge. The same is required from the theologian if he become a priest, as well as from the lawyer. All candidates must submit to two kinds of tests—the university and likewise the State examination. In the first all the examiners are professors. The State Commission requires, first of all, that the candidate shall present the evidence that he has passed the university examination, which gives certificates or degrees of three grades Then the State supplements the knowledge thus evidenced by requiring its officials (doctors, lawyers, and ministers) to show further qualifications which entirely relate to *practical* subjects. At this examination university professors are associated with other examiners. We would, in fact, think an examining board without university professors defective. It is true that we do not think every medical man should be an M.D. The State licenses him to practise after he has passed the university test The M.D. is now looked on as a university honour, only imposed as a necessity on men who intend to follow an academic career. You will understand from this that the State examination does not affect the independence of our universities, because the university examination precedes the State examination. It is the university that determines the *scientific* qualifications of the candidate, and what practical tests the State cares to apply to its officials do not concern us."

illustrated in the Bills now before the Prussian Parliament in respect to theological studies. The State proposes to insure that every clergyman shall possess liberal culture, and with this view, whether Protestant or Catholic, he must go through a curriculum of classics, literature, philosophy, and natural science in the universities, and not merely in special seminaries. The examination in these subjects is to be in the hands of the State and not in those of the bishops. The curriculum of study belongs to the university, the evidence of its fruition to the State. Such paternal functions of the State, even though chiefly exercised through university professors, are rather incomprehensible to us. Doubt is expressed in Germany itself as to whether it is wise for the State to secure its end by examination, for Professor Planck, in his recent rectorial address at Munich, counsels the State to take other means for obtaining good professional men "than its narrow and doubtful" examining systems. While no country in the world has benefited so much as Germany by its university system, none, except China, has suffered so much as France by giving a preponderance to examination, and subordinating to that the teaching functions of universities. I have shown fully elsewhere* how France now admits that the poverty of intellect displayed during her recent crisis was the consequence of her having sacrificed the national intellect to a uniform State-examining system.

It is not easy, in the short time at my disposal, to show you how Germany has managed to reconcile free university teaching with a State-examining system, without injurious consequences to intellectual development, but this has been well done by Matthew Arnold. Certainly, German ideas of examination are as opposite to those that prevail in our universities as they can well be. With us examination is the end of university life, while in Germany it is the mere test of a well-ordered course of study. All "*specielle Vor-*

* "Teaching Universities and Examining Boards."—*Ante.*

studien" are expressly discouraged, and the examination aims at the proof that the student has attained "*das Wesentliche und Dauernde*," or a substantial and enduring result of study. Under our examining systems cram flourishes; in Germany it has little existence, for the examination, which is a subordinate function of their university system, aims at the proof of intellectual development fitted for a future career of usefulness.

Let us apply these national experiences to the satisfaction of a reasonable demand that the medical practitioners in this country should at least possess a minimum standard of efficiency. While the State has a right to demand that, it is clearly its interest and policy to effect its purpose in such a way as will insure maximum and not minimum qualifications. It is not wise to have either uniformity in teaching or in examination; for differentiation is as important in intellectual as it is in physical life. A one-portal system is based on uniformity, and it would effect it as surely on the student, as the single hole of the wire-drawer does upon the wire drawn through it. To avoid this, we now find the one-portal system abandoned for a three-portal system, one door of entrance being proposed for each section of the United Kingdom.* No doubt this is better, for it would secure at least national differentiation, though it would still cramp professional development in each section of the country. The only justification for the interference of the State is the assumed position that the nineteen licensing bodies, by their competition, have a tendency to lower qualifications. I doubt this as a fact, but I have no doubt whatever that a downward competition would be the inevitable result of a single examining board. Though the corporations, under conjoint schemes of examination, continue to give the licence

* When I held the office of Vice-President of the Council I carried through an Act for medical qualifications on the principles enunciated in this address.—L. P.

in name, they will be virtually superseded in testing the fitness of candidates to receive the titles which they confer. It does not require a sage political forecast to know that such a conjoint system possesses neither the conditions of permanence nor of strength. Coherence it cannot have, for the public would soon doubt the wisdom of continuing corporate powers when they are exercised in name and not in reality; and, as soon as the danger becomes patent, the corporations will dissolve a voluntary union which saps their existence. Unless they wake quickly to a sense of their danger, the system may be riveted by legislative action. The corporations are not teaching, but licensing and examining bodies; and when they resign these powers to a conjoint body of examiners, it becomes very difficult to understand why provincial candidates, at least, should care to belong to them, or why the public should prolong their existence. I should regret their extinction, because I value them as productive of professional strength and of *esprit de corps.* It is by such unions that the medical profession possesses political power and influence. The effect of their absence may be seen in such incoherent professions as the Merchant Navy, which contains men of high qualifications, but possessing small power, from want of bonds of union such as the Medical Corporations afford. The only bodies which are likely to be long survivors of a conjoint examining system are the universities, for they have specific teaching functions, which would still remain after the corporations have been swallowed by the ogre of conjoint examinations. Should the State, under the influence of the popular cry, assume the function of examination, it would be productive of the least evil, if it limited that to strictly clinical subjects. The teaching bodies would then occupy themselves with laying down a sound scientific and systematic basis of professional knowledge; while the State would gain assurance that the practitioner could apply his science to the actual practice of

his profession. A second contingency is possible, for present State interference may be the future forerunner of free trade in medicine; because, when the corporations succumb to the feeling of their inutility, and the State becomes disappointed with the results of a minimum examination, medical men as individuals may have to submit to whatever relations the State cares to establish with them. When legal recognition is asked by medical men from the State, it has a right to fix their qualifications in the interest of the public. That right follows legal recognition and the bestowal of civil rights, but the State is not bound to repress irregular practitioners who demand no recognition; and the time may come, when the profession has yielded itself to the influences of the State, that the latter may look upon regular and irregular practitioners as outside its functions altogether. In other regions of politics, as, for instance, in regard to religion, there is a tendency for the State to cut itself adrift from complications of this sort. Under the present system the medical profession is in no danger, for it regulates its own affairs, and has little connection with the State. The less it has to do with it the better, if the dignity and independence of the profession be consulted. The Medical Council is not supported by imperial taxation, but by professional contributions. Though it is not constituted with that popular representation which ought to be the basis of such an assembly, it is in theory and in fact a representative body. Into this the State also sends members of the profession, always men of a representative character; and as long as it continues to do so, its right is not likely to be questioned, though it is doubtful in principle. The Medical Council needs reform, but this may be effected without subverting the teaching and examining functions of universities and corporations. I am sure, when the medical profession realises the disastrous effects which uniform examining systems have produced in other countries on national intel-

lectual development, that it will be slow to introduce them into this kingdom, or to relinquish the independence of the profession for the doubtful advantages of direct State recognition. No doubt the Medical Council ought to take ample securities, either by efficient inspection or by participation in examinations, that every separate examining board never descends below a minimum standard of qualifications; but, in doing this, so far from seeking uniformity in examinations, they should encourage variety, and should welcome all aims at higher qualifications on the part of the examining bodies, stimulated to differentiation by whatever methods or subjects their teaching staffs choose to introduce. It would, of course, be possible in a central examining system to have degrees of qualification, but such a plan would assuredly destroy variety in teaching, still more effectually than a minimum test, because it would suppress university degrees and corporation honours, and substitute State uniformity in honours and in the means of attaining them.

After what I have said, you will see how impossible it is for me, as representing two Scottish universities, to yield to a popular cry of a one-portal system. It is a matter of indifference to Oxford, Cambridge, and the London University, whether they accept or refuse such a system. Their medical degrees, taken altogether, do not equal one of the universities which I have the honour to represent. The teaching functions of the English universities, as regards the professions, have little more than a nominal existence. The Scotch universities, both as to teaching and graduation, are in most intimate connection with the people of Scotland, and derive their whole strength from them. You recollect that even Hercules was not a match for the Libyan giant Antæus, as long as he was in contact with his mother earth, whence all his strength was derived; but when Hercules lifted the giant from the earth he lost his power, and was easily squeezed to death. The Scotch universities feel that

a conjoint scheme of examination would part them from the people, and turn their strength into weakness. With the remembrance of what happened to Antæus of old, are you surprised that they cling with all their force to the people, and decline to be severed from them, lest they receive the embrace of death from some Hercules in the guise of a medical officer of the Privy Council or Local Government Board? The Scotch universities will cordially welcome any system of thorough inspection of their examinations on the part of the Medical Council, or they will willingly receive accessory examiners, who may be appointed by the Council; but they resolutely oppose a concentration of examinations, which all experience has shown to be most detrimental to higher intellectual culture.

I have now finished, and I trust I have convinced you that it is not only possible, but easy, to put our universities into harmony with active professional training. To do so is only to bring them back to their original purpose of liberalising the professions. Liberal culture must, however, have a wider meaning than it now has, if this harmony be re-established. Each profession has its own foundation of liberal culture. At present the universities try to build all professions on one uniform foundation, though this is as foolish as it would be to build a palace, a gaol, or an infirmary, on a single ground-plan common to all. The professions have indicated, by their special literary examinations, what their several foundations should be; and if the universities know how to extend their obligations to modern society, they should have little difficulty in again assuming their original purpose of affording a liberal culture to the professions. The universities would thus gain in strength, and the professions in dignity and in efficiency.

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